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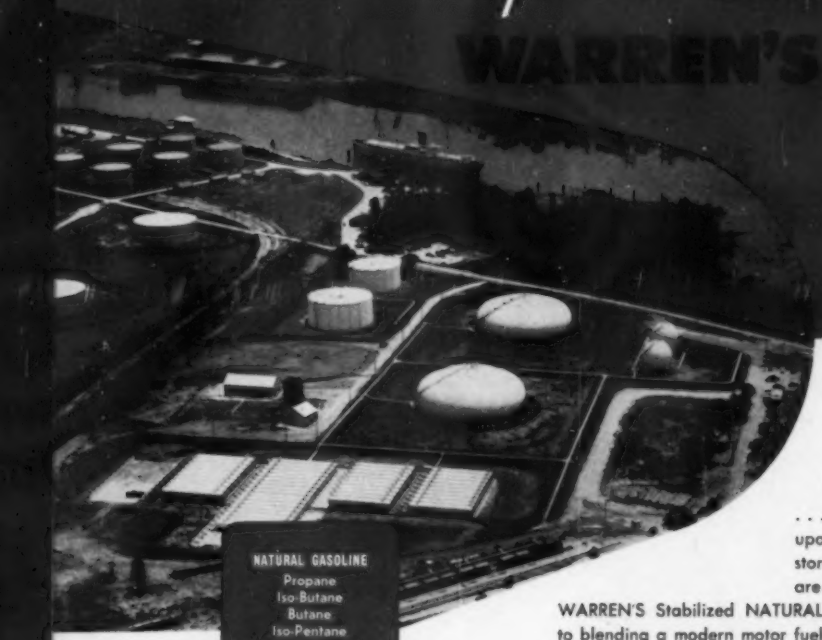

WARREN'S *Stabilized* NATURAL GASOLINE and STA-VOL-ENE

. . . or when you want it! You can depend upon WARREN'S expanded production, storage and transportation facilities. We are ready to meet your demands for WARREN'S Stabilized NATURAL GASOLINE or STA-VOL-ENE, so vital to blending a modern motor fuel. When you blend with WARREN'S, you are assured of higher octane rating, greater volatility and low front end factors which are synonymous with a Knockless, Quick-Starting, Carbon-Free, Uniform motor fuel with Smooth Acceleration . . . Its Increased Vapor Pressure decreases sales resistance at the filling station.

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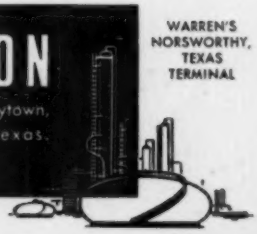

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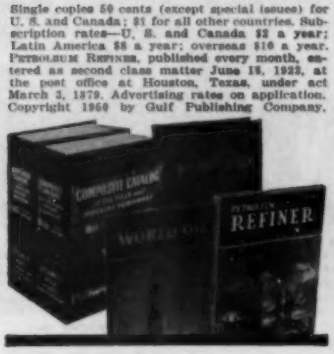

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PETROLEUM
REFINER
Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management
R. L. DUDLEY, President A. L. BURNS, General Manager
VOLUME 30, No. 5 MAY, 1951

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I-R Equipment Serves the

World's Largest Cat Cracker

and the

World's Largest Vacuum Still

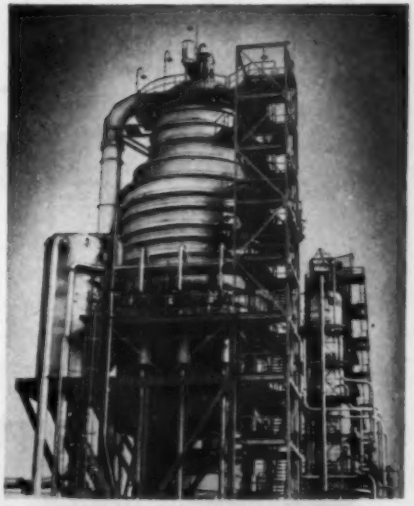
at the huge Esso *Bayway Refinery*

Big things have been happening at the Esso Standard Oil Company's Linden, N. J., refinery.

Recent expansion included the addition of a new fluid catalytic cracking unit, and a new vacuum pipe still—*each, the largest of its kind anywhere in the world!* Both units were designed and engineered by the Standard Oil Development Company. Construction was by C. F. Braun Company of Alhambra, Calif.

In an installation of this size there is a tremendous amount of equipment required . . . blowers; compressors, both reciprocating and centrifugal; condensers; ejector units; pumps, including condensate, circulating-water, feed water, boiler-feed, etc. This machinery serves the cat cracker and the vacuum still both directly and in supporting roles.

It is significant to note that a large part of this machinery is Ingersoll-Rand equipment . . . machines that are built to stay on stream.



The following I-R equipment was furnished for maintaining the required vacuum on the new Vacuum Pipe Still:
DF-120 welded-steel-plate barometric condensers for use as precoolers.
Two-stage, single-element ejector units, each consisting of:
An 18 x 12 first stage ejector
A DF-3 barometric intercondenser
An 875-F40 second stage ejector.

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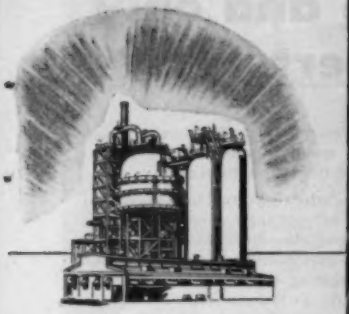
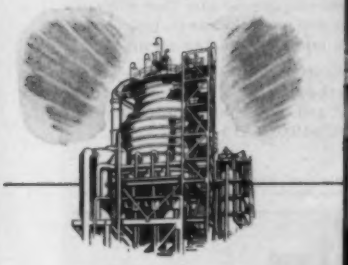
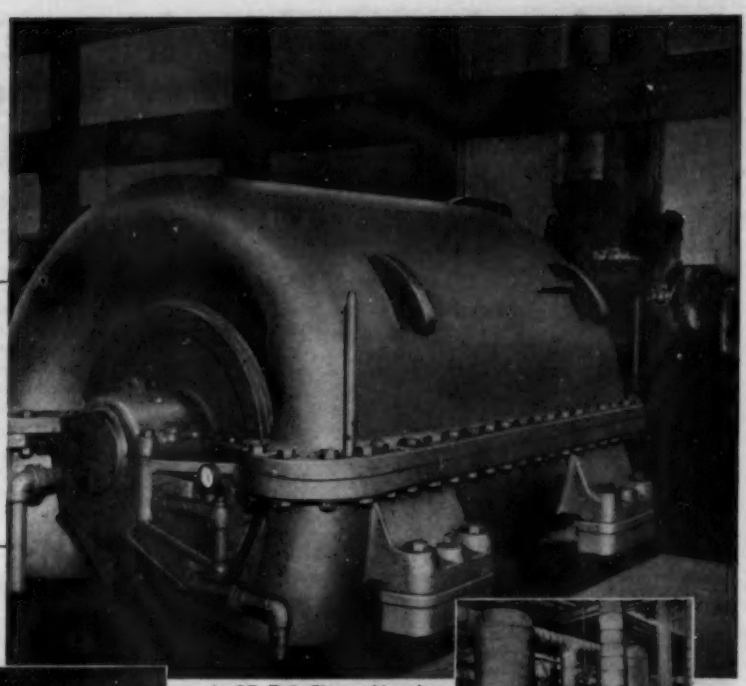
COMPRESSORS • AIR TOOLS • ROCK DRILLS
TURBO-BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS
DIESEL AND GAS ENGINES



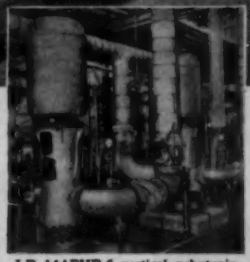




An I-R Turbo-Blower, driven by a 4530 hp Ingersoll-Rand turbine, furnishing air for catalyst blowing.

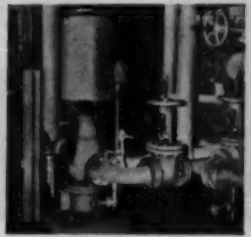
An I-R centrifugal gas compressor, driven by a 2750 hp I-R turbine, serving the absorber tower. This is the first installation using centrifugal compressors for this service.

A 3GTR-3 feed water pump. Associated equipment includes I-R 1MRVH15 condensate pumps and an I-R 1½ BSFL condensate pump.



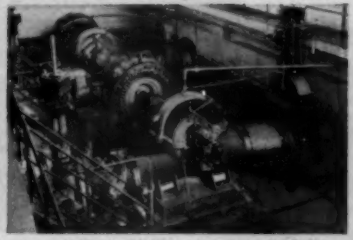
I-R 14APHR-6 vertical cobutanizing reflex pumps with Cameron shaft seals.

I-R 4HT4 high-pressure boiler feed pumps installed at the main boiler plant.

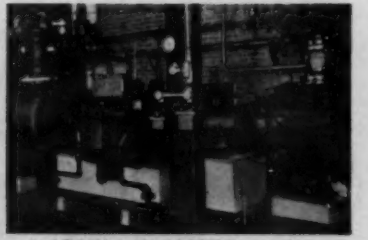


An I-R 8APHC-3 vertical condensate pump used with the surface condenser.

An I-R Surface Condenser serving the gas-compressor turbines. The condenser is a two-pass, vertically divided unit.



Ingersoll-Rand 24ALV salt-water circulating pumps serving the salt water pumping station, which is 100% I-R equipped.



An I-R 21½ & 13 x 12 HHK-2 ammonia compressor with 500 hp synchronous motor. Unit is equipped with 5-step clearance control.

Which tube steel is the one and only for you? Ask the experts!

This month's report is on: **SICROMO 5S**

High degree of surface stability under oxidizing conditions up to 1500°F., makes it excellent for air preheater tubes, recuperator and superheater tubes, incinerator equipment. In cracking tubes, offers good resistance to corrosion by hot petroleum and excellent stability up to 1500°F.

23 TIMKEN STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20
DM-2	2¼% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 5	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

**Not available as seamless tubing at the present time.*

One and *only* one high temperature tube steel can give the best life/cost ratio under a particular set of heat, pressure, corrosion and oxidation conditions.

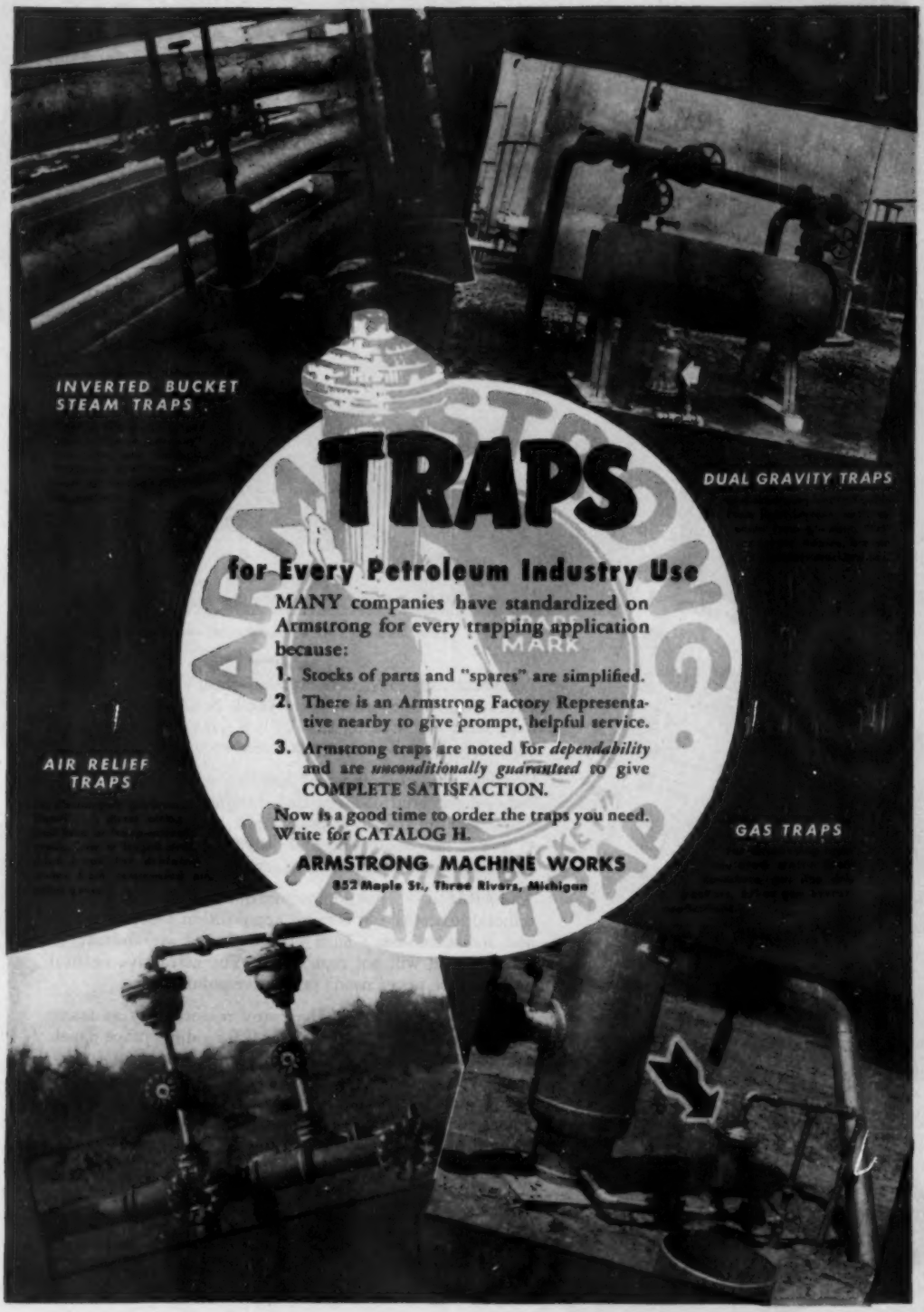
To make sure you select the right steel for *your* operating conditions, get the help of the recognized authorities on high temperature steels—the Timken Company's metallurgists. Their knowledge has been gained through the development and testing of 23 analyses to solve specific high temperature problems. They'll help you choose the one steel out of the 23 that will give you the most life per dollar. And you can be sure that analysis will be uniform from shipment to shipment, because of the Timken Company's complete quality control.

Let our "RSQ"—Research, Supply, Quality—solve your tube problems. Ask the experts! The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

Photo shows furnaces in the Timken Company's experimental heat treating laboratory. Pioneering research on high temperature steels' properties is one big reason for the Timken Company's leadership.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing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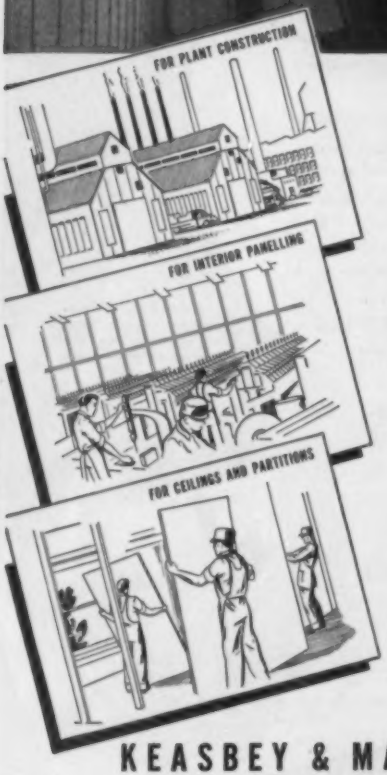

Whatever your construction plans—interior, exterior, new structures, or modernization—you'll build better, at less cost, with "Century" APAC . . . Keasbey & Mattison's versatile asbestos-cement structural sheet.

Consider the advantages of building with APAC: It's a low-cost material of stone-like durability. Application is quick and inexpensive: Sheets are large size (standard 4′ x 8′); are easily cut and fitted on the job; can be fastened with ordinary nails or screws. Labor costs are low.

And APAC needs but a minimum of maintenance! The all-mineral asbestos and cement composition resists weather and moisture—*can't burn*—is unaffected by rodents or termites and will not rust or rot. The attractive natural gray surface never needs protective painting!

These are just a few of the many reasons why so many plants are using "Century" APAC for siding, office panelling, fire-resistant sheathing in shops and stock-rooms, storage bins, linings for elevator casings, shower stalls —to name but a few uses. We'll be glad to send you complete information on "Century" APAC, and the name of your nearest distributor. Write us.

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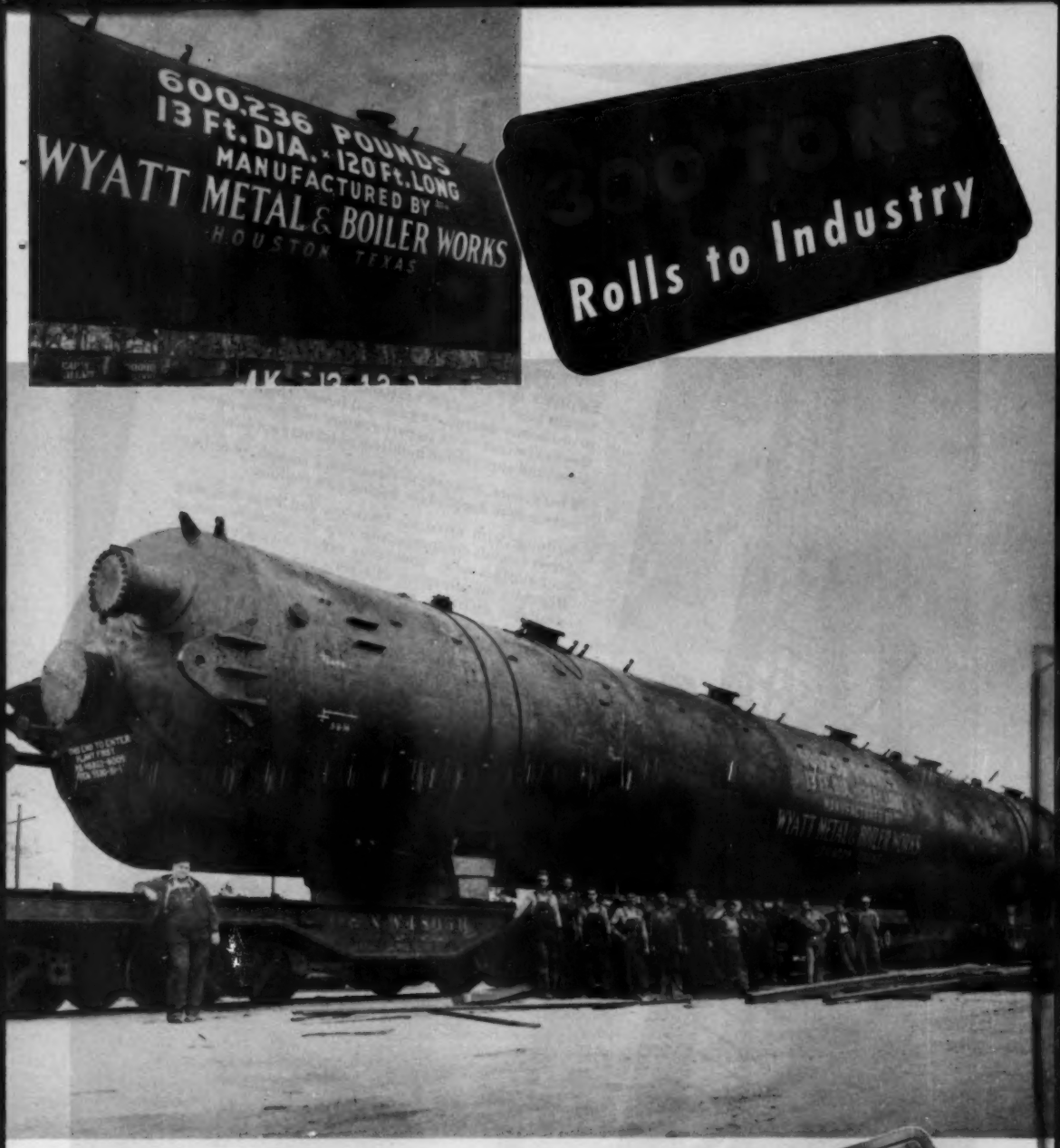
K&M Cat in asbestos

Nature made Asbestos...
Keasbey & Mattison has made it serve mankind since 1873



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AND ERECTORS SINCE 1913

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UNDER PRESSURE
● Where pressures are highest and temperatures hottest, the situation calls for refinery equipment made of Republic ENDURO Stainless Steel. For, ENDURO is unflinching in the face of punishing pressures, and maintains its great strength at both scorching and sub-zero temperatures.
ENDURO is a "high-test" metal: high in strength-to-weight ratio . . . high in resistance to rust and corrosion, to ordinarily destructive gases and fumes . . . high in resistance to fatigue—with its performance and staying power tested and approved in hundreds of refinery applications.
What's more, it is easy to clean—has a smooth, pore-free surface that discourages coking and fouling.
Building with ENDURO Stainless and Heat-Resisting Steels extends equipment life, cuts downtime for repair and replacement, conserves other critical materials. Republic metallurgists will help you apply the many available ENDURO analyses to full advantage. Write:
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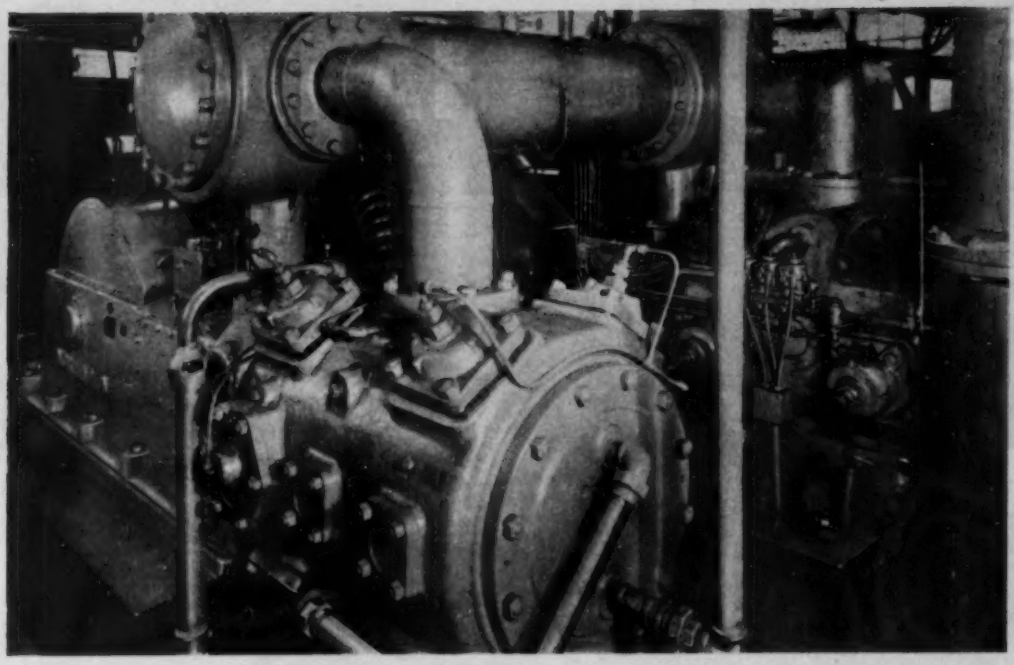


Only Pennies for maintenance!

Except for replacement of a valve strip after many months of service, the Worthington Air Compressors at Standard Oil Company in Baltimore have operated two, three and four years without any maintenance expense.

Such performance proves the economy and dependability of the Worthington Air Compressor. In addition to the exclusive Worthington Feather* Valve (simplest, lightest, tightest ever built), the DC2 model illustrated above also has Worthington's own automatic variable capacity control—most accurate, flexible and simple control available. And Worthington's high-efficiency intercooler needs less water, less power, less attention.

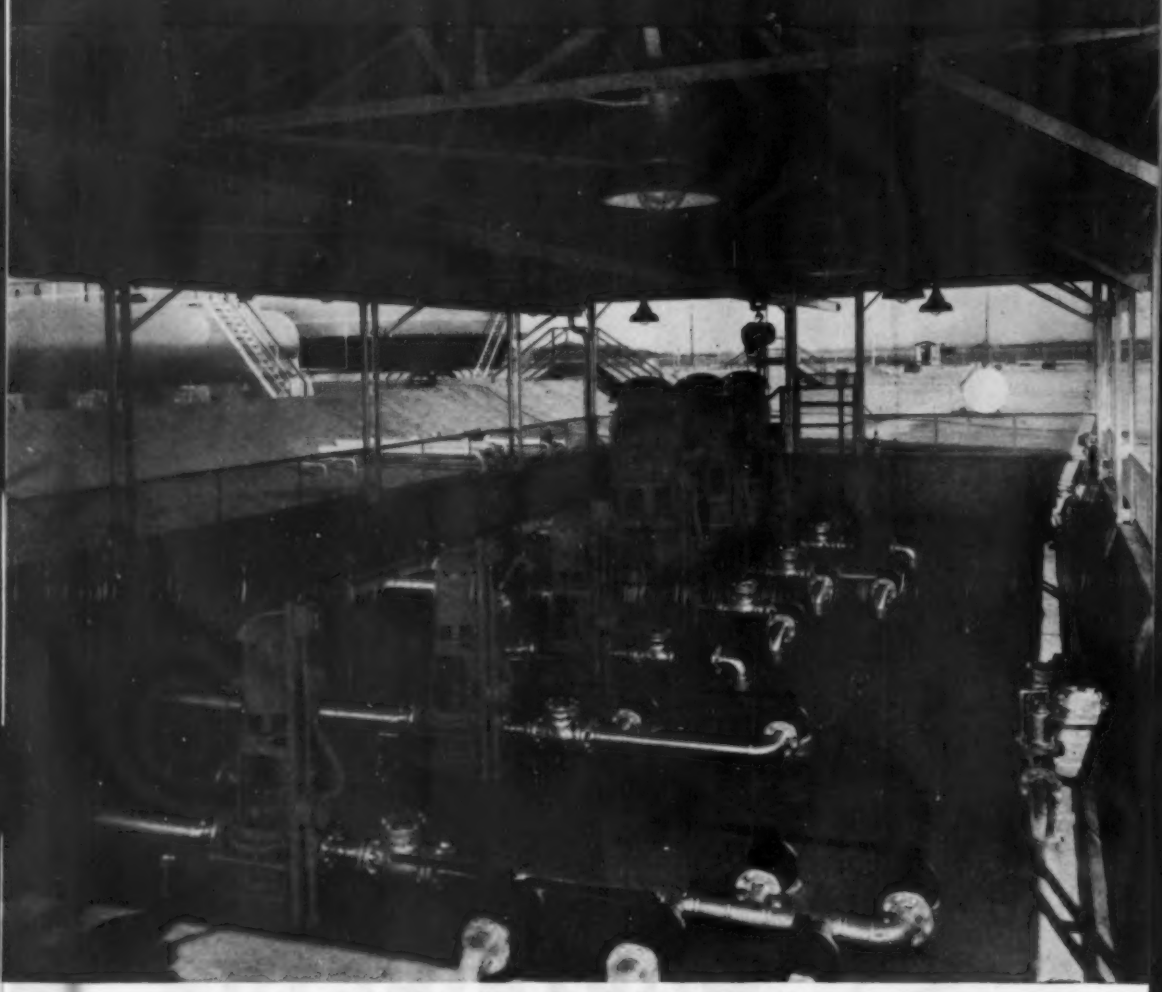
To become familiar with the "why" of Worthington's 50-year leadership in compressors, write for bulletins on Worthington compressors. And for a wide range of equipment for the petroleum industry, ranging from pumps and engines to refrigeration equipment—investigate the *more worth in Worthington*. Worthington Pump and Machinery Corporation, Compressor Division, Buffalo, New York.

WORTHINGTON

*Reg. U. S. Pat. Off.

K1.3

PRODUCTS HANDLING . .



Nordstroms in a products pipe line pumping station.

Nordstrom Valves

NOW AUTOMATICALLY LUBRICATED WITH Hypermatic (TRADE MARK) (PATENTS APPLIED FOR)

Hypermatic lubricant makes tremendous improvement in Nordstrom valves. Being *energizable* it self-seals, self-feeds, keeping the valves in a 100% lubricated condition, for prevention of leakage and insuring most positive operation. Maintenance costs are cut to the minimum.

. . infinitely safer with NORDSTROMS

In handling petroleum products you first consider *safety*. That calls for ever-tight valves, free from freezing, free to turn easily, positively sealed around the ports regardless of line pressure. Note how perfectly the Nordstrom design fits these specifications. The tapered plug is pressure lubricated, held tight on its unexposed seat by resilient means; the lubricated seat permits easy rotary turning of the plug, as contrasted to metal-to-metal unlubricated seats in common types; "Sealdport" lubrication surrounds each port to prevent leakage; the plug can be hydraulically jacked when required.

For handling gasoline, distillates, butane, propane and other petroleum products, Nordstroms have no equal. They keep upkeep down.

Put Nordstroms to ANY test

Install them, for test, side by side with any other type, check their operation, compare their performance . . . make a record of maintenance costs. You will find them to be tops in performance—and by far the most economical valves you have ever used. Successful operation of over 5,000,000 Nordstroms is proof of performance.

ROCKWELL MANUFACTURING COMPANY

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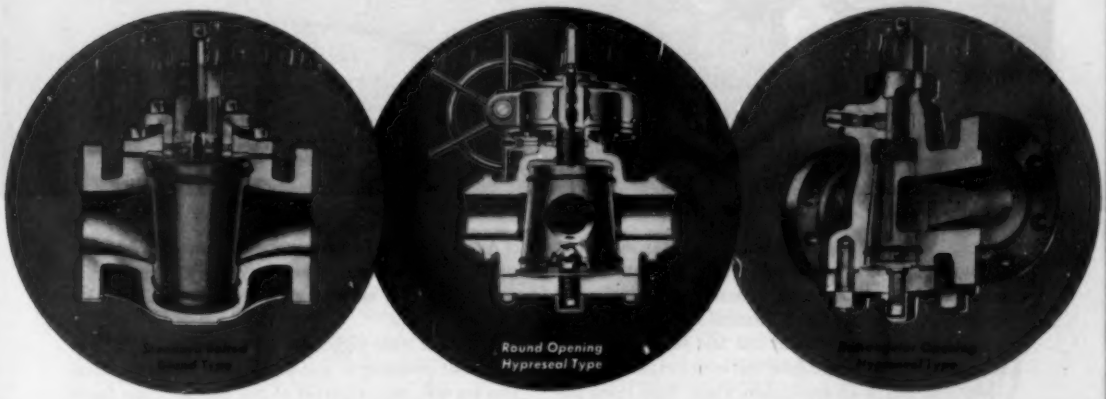
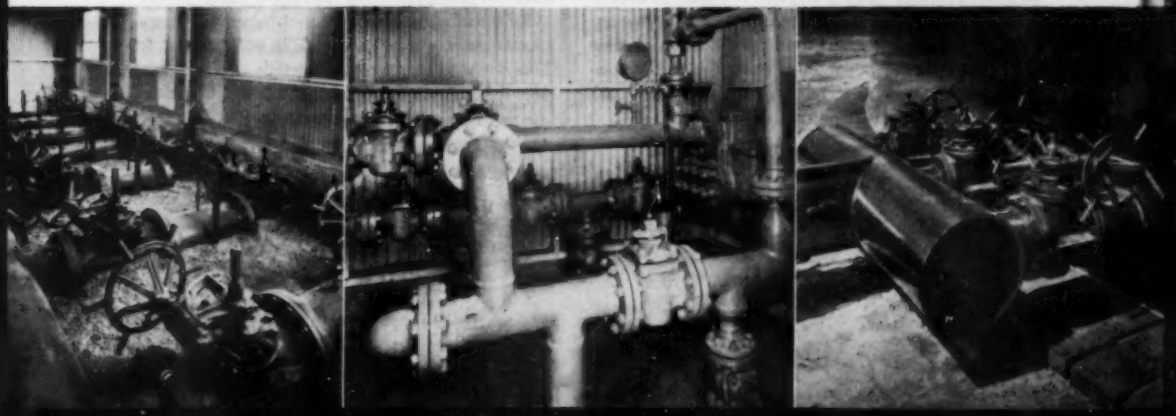
. . . and leading Supply Houses • Export: Rockwell Manufacturing Co., International Division, 7701 Empire State Building, New York 1, N. Y.



Nordstrom valves in a products pump station.

Nordstroms on products line in pump house.

Nordstroms on connections to gasoline storage tank.



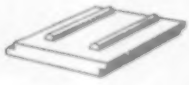
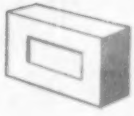
Among the various Super Refractories by CARBORUNDUM you will find several unique properties not usually associated with refractory materials. Amazingly high resistance to abrasion is one. Another is chemical stability – particularly in the presence of acids and acid fumes, and even at temperatures far above those that most metals will stand.

An example of an application where these characteristics are important is in ducts to and from SO_2 converters. Here, high velocity SO_2 and SO_3 gases at 1100°F create very corrosive and erosive conditions. To counteract the chemical attack and the scouring action of these gases, linings made of CARBOFRAX silicon carbide material (one of the Super Refractories by CARBORUNDUM) are used in all vulnerable portions of the ducts.

A quite similar use for CARBOFRAX linings is found in muriatic acid furnaces, hydrogen cyanide converters, SO_2 and SO_3 recovery systems, sulphur burners and other related equipment.

Do any of these suggest possible applications? Bear in mind that immunity to acid attack and resistance to abrasion are only two properties of this one particular Super Refractory. As you can see in the box opposite, CARBOFRAX materials have many other interesting characteristics.

Information on *all the types* of Super Refractories by CARBORUNDUM is now available in booklet form. It outlines just what these unique materials can be made to do. May we send you a copy? No obligation, of course. Just use the coupon on the opposite page.

or corrosive fumes and you still this material

This advertisement — one of a series — is presented in the belief that in the unusual properties of the various Super Refractories by CARBORUNDUM lies the key to many new or improved processes. We would like to talk over specific jobs with anyone who sees such possibilities.

Principal characteristics of CARBOFRAX Super Refractories

- Outstanding abrasion resistance — at all temperatures from room to well above 2600°F. Successfully used to line coke and ore chutes and dust collectors. A good example of high temperature use is for skid rails in slab-heating furnaces.
- Far stronger, in all temperature ranges, than practically all other refractories.
- Very high thermal conductivity. Made-to-order for checkers, recuperator tubes and tile, muffles, hearths, linings for water-wall boilers, and similar applications.
- Low and uniform coefficient of expansion — .000005 per degree C between 25° and 1400°C. Spalling is rarely experienced.
- Readily withstand temperatures up to and often well above 3000°F. Excellent heat-shock resistance. Unaffected by temperature changes that will quickly ruin other refractories.
- Remain extremely hard at elevated temperatures, and therefore resist clinker or slag ahesions.
- Inert to acid attack.

CARBOFRAX refractories are available as brick and as special shapes molded to very close tolerances—including fitted joints, tubes, etc. They are not, however, a universal cure-all, and should be applied with caution where molten metallic oxides or molten bases are present. They will not withstand hydrofluoric acid. However, there are other Super Refractories by CARBORUNDUM that are applicable in these cases—particularly MULLFRAX electric furnace mullite, ALFRAX electrically fused alumina, and MONOFRAX fused cast refractories.

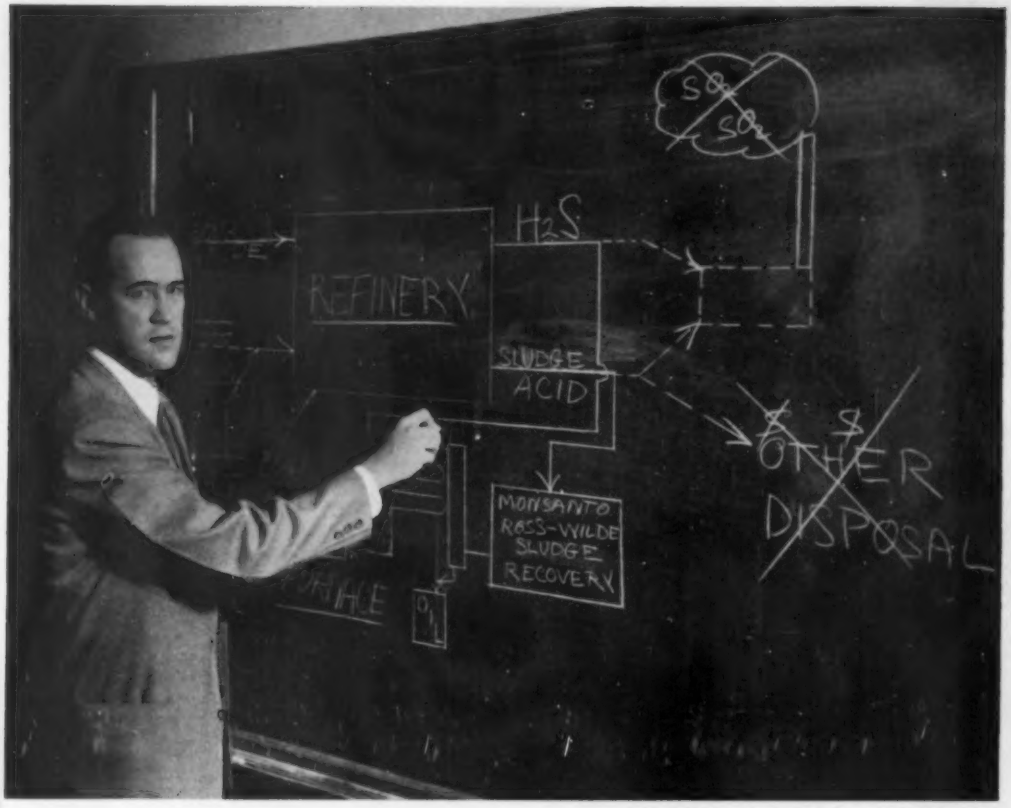
In our new booklet on Super Refractories, you'll find information about materials which, for example, are highly resistant to erosion by molten glass; or make excellent insulators; or are unusually light in weight. The special qualities of these special-purpose refractories may go hand-in-glove with one of your processes. Why not check up? The coupon will bring you the story—or one of our engineers will be happy to talk over your specific problems. We believe it could be mutually profitable.

THE CARBORUNDUM COMPANY
Refractories Division **Perth Amboy, N. J.**

"Carborundum," "Carbofrax," "Monofrax," "Mullfrax" and "Alfrax" are registered trademarks which indicate manufacture by The Carborundum Company

Dept. T-51
Refractories Div., The Carborundum Co.
Perth Amboy, New Jersey
Please send your free booklet on properties of Super Refractories

Name_____
Position_____
Company_____
Street_____
City_____ **Zone**_____ **State**_____



T. R. HARRIS, of Monsanto Engineering Sales, diagraming the Monsanto-Ross-Wilde process.

Sulfuric acid—problem today and tomorrow

Today's shortage of sulfuric acid is a problem that may well extend into the future. There are two factors indicating that it will remain long after the present emergency is over. First, sulfuric acid, most important of the heavy chemicals, is being used in more and more processes. Second, regardless of sulfur supplies, the increased use of sulfuric acid may make it difficult to obtain in desired quantities.

You can take a long stride toward solving *your* problem by recovering fresh, clean sulfuric acid from most types of refinery waste acids and from H_2S with a Monsanto-Ross-Wilde Sludge Recovery Unit. This unit can be linked with your present sulfuric acid plant, or can be built as a unit with a Monsanto-designed contact plant which produces new, white acids.

Monsanto-designed units will handle any type of fluid sludge without alteration, hence the plants will not become obsolete through changes in your processes which may result from reduced alkylation demand. Equipped with automatic controls, these easy-to-operate plants require a minimum of manpower.

Why not investigate this means of easing your sulfuric acid and waste disposal problems? At your request, a Monsanto representative will bring you complete information without cost or obligation. Write, wire or telephone MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1776-E S. Second Street, St. Louis 4, Missouri.

Advantages of Monsanto-Designed Plants

AUTOMATIC CONTROLS, incorporated directly into the package unit, reduce manual attention to a minimum in the Monsanto-Ross-Wilde installation.

VARIOUS TYPES OF SLUDGE, containing low or high concentrations of acid, can be processed in Monsanto-designed plants.

EVEN HIGH-VISCOUS SLUDGE can be processed in the Monsanto-Ross-Wilde Unit by mixing it with more-fluid sludge.

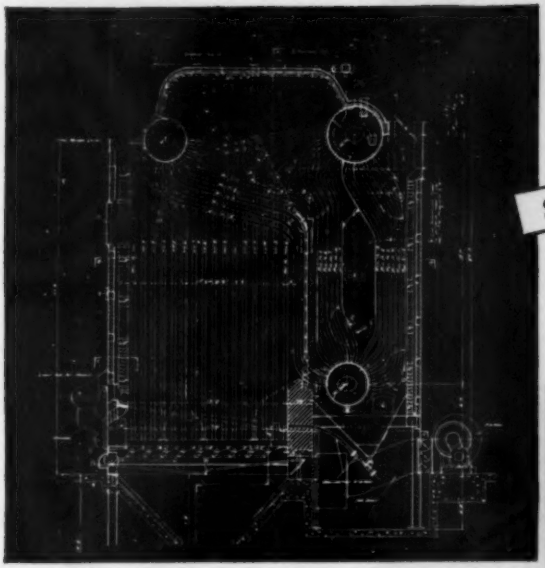
☆ ☆ ☆ ☆

WRITE FOR BOOKLET *describing the Monsanto-Ross-Wilde process of sludge acid recovery.*

MONSANTO
CHEMICALS — PLASTICS

SERVING INDUSTRY...WHICH SERVES MANKIND

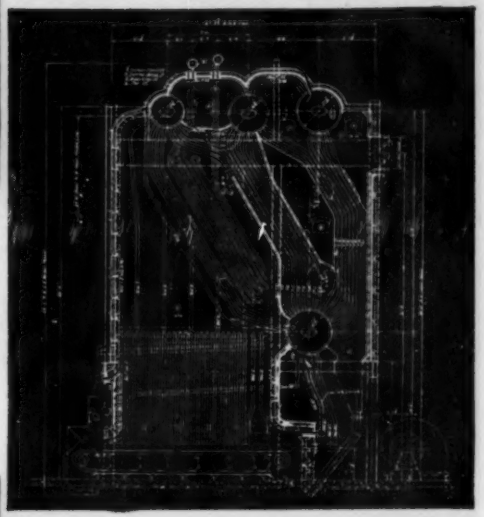
Quick Steaming at all Ratings!



Carry high overloads with high efficiency

SPECIFY Vogt

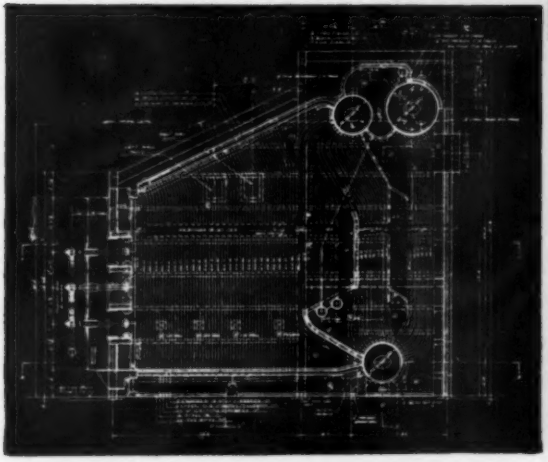
STEAM GENERATING UNITS



CLASS VL — Two 27,500 pounds per hour units, installed at Brown-Forman Distillers Corporation, Louisville, Ky. Features large furnace volume in limited space, with high ratio of radiant heating surface.

CLASS LE — Mt. Carmel Public Utility, Mt. Carmel, Illinois, is served by this 60,000 pounds per hour unit. Generous steam liberating surfaces and steam space permit wide fluctuations in load.

CLASS VR — 70,000 pounds per hour steam generator at Humble Oil and Refining Company, Johnsue, Texas. An efficient, high-duty unit with water cooled furnace, using refinery gas fuel.

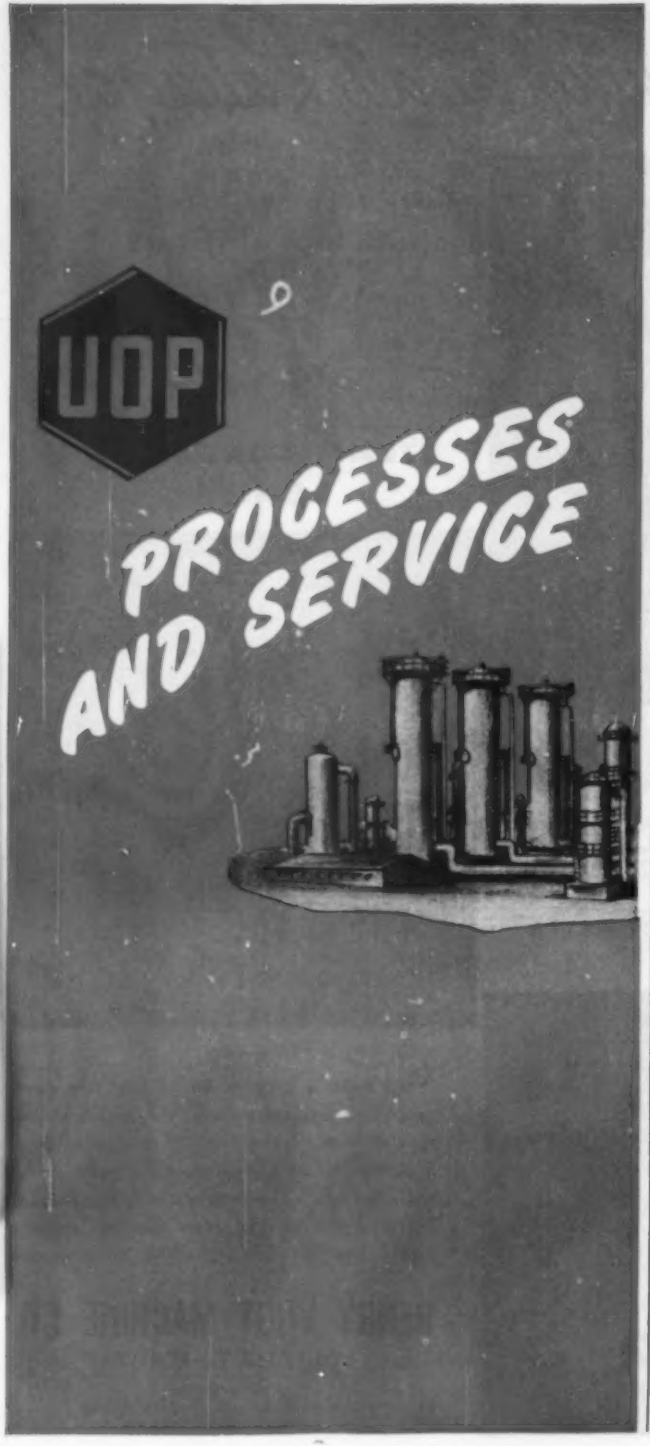


Vogt builds a complete line of bent tube steam generators, designed to burn solid, liquid, or gaseous fuels to meet specific operating conditions. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Bulletins with general information and showing typical installations are available upon request.

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

BRANCH OFFICES:
NEW YORK, PHILADELPHIA, CLEVELAND
CHICAGO ST. LOUIS, DALLAS



Platforming Unit to Upgrade Kendall Straight Run—Add Facilities for Defense

By Howard V. Smith,
Refinery Superintendent
Kendall Refining Company

Our decision to install a 1500 barrel Platforming unit was made in recognition of the constantly upward trend of gasoline octane ratings for the knockless operation of increasingly higher compression motors. However, from the beginning possibilities inherent in this type of plant for the production of petro-chemicals were thoroughly explored and excess capacity was incorporated in the design so that modification could be made at a later date for that purpose.

Howard V. Smith

Competitive Situation Called for Higher Octane

A survey of gasoline quality in the nearby Pittsburgh area revealed the following average octane ratings for house brand and premium motor fuels:

	Research Method	*Motor Method*
House Brand	86.2	80.2
Premium	91.8	83.1

Bradford Grade Penna. crude, to which Kendall, being one of the largest producers of 100% Pennsylvania grade lubricating oils, is committed, contains a relatively high proportion of low octane gasoline and naptha which cannot be brought up to the above standards by the addition of tetraethyl lead alone.

This crude runs about 40% gasoline and naphtha, boiling up to 400°F. end point. Sulphur content is low and the combined product has excellent volatility. The research octane number is 50 clear and 70 with 3cc's TEL. Twenty-three per cent of the crude oil is available for cracking in the Dubbs continuous coking plant which yields 77 per cent of cracked gasoline and polymer on the charge. Thermal reforming of straight run naptha is included in the Dubbs plant operation.

All Processes Explored

Our engineers made a thorough study of available processes before reaching a decision that Platforming offered the most economical solution to our problem. Engineering studies showed that thermal reforming to the extent considered economical would still leave the anti-knock quality of the product short of the ultimate goal.

Pilot plant studies in the Universal Oil Products Company's laboratories demonstrated that the Platforming process would convert the 400 end point full boiling

range gasoline into 95 octane gasoline with 3cc's TEL, with a yield of more than 90 per cent by volume. Details of this pilot run are expressed in the following table:

Inspection of Kendall Straight Run, Fractionated Reactor Charge and Stabilized Platformate

	Full Boiling Range Straight Run Gasoline	*Reactor Charge*	*Platformate*
API Gravity	64.9	58.0	58.2
IBP	90	180	102
5%	117	201	134
10%	136	211	150
30%	198	235	188
50%	243	264	225
70%	290	306	262
90%	358	360	327
95%	381	377	364
EP	394	399	411
RVP	10.3	0.7	9.5
Octane Ratings			
F-1 Clear	50.1	40.2	84.1
F-1 3cc's TEL	69.7	61.2	95.3
F-2 Clear	49.5	38.0	78.8
F-2 3cc's TEL	69.5	60.8	87.9

Consideration of Defense Requirements

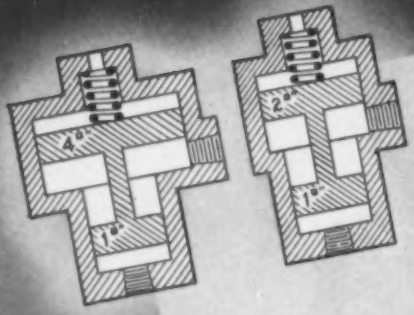
Another consideration was the fact that in the event of a drastic shift in requirements due to the impact of a defense or war economy on the nation, our Platforming facilities could be converted to the production of aromatics, aviation gasoline components, benzene, toluene and other petro-chemicals which might be needed for military purposes. While this conversion would require certain modifications in the unit itself, as well as additional feed stocks from outside sources, the change-over would not radically disrupt our operations and full utilization of the new unit would be possible.

Special Design Features

The plant design for our Platforming unit, incorporates some special features, particularly applicable to our circumstances. Since our charging stock is well fractionated and free from heavy ends, it was decided that a suitable reactor charge stock could be prepared from it by distilling off the light ends in a depentanizer. Utilization of this method instead of a prefractionator, reduced size of the equipment as well as the operating cost.

Air contamination of the charge stock will be minimized by blanketing the charge tanks with dry gas from the vapor recovery unit of the refinery. The depentanizer overhead will be depropanized to produce a blending stock for volatility control. Depropanizer overhead will be charged to the Platformer stabilizer to reduce butane loss. Recycle gas and reactor charge will be mixed before entering the heater and heated as one stream instead of separately.

Our new Platforming unit was designed by Universal Oil Products Company in collaboration with our engineering department. It is being erected by Procon Incorporated, and is expected to go on stream in March of 1951.



Do You Know Why

'HIGH RATIO' TRAPS *by* NICHOLSON DRAIN CONDENSATE FASTER?

IF you were asked, "Which of the two differential pistons sketched above will require the least pressure drop before the piston assembly can move up?" you would obviously answer, "The one at the left". Because of the higher ratio between the areas of its upper and lower pistons.

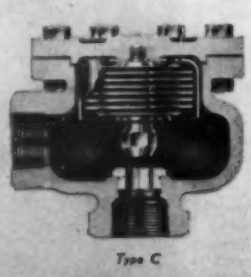
Now the line pressure in a thermostatic bellows trap is analogous to that in a differential piston. The higher the ratio of bellows area to discharge orifice area the less the pressure drop required before the bellows will contract and open the discharge valve.

Getting down to cases, the Nicholson thermostatic trap has a larger bellows than any other trap of this type, while its discharge valve orifice is approximately equal in size to any other trap. This gives a higher ratio and causes the Nicholson trap to operate on the least temperature difference between steam and condensate.

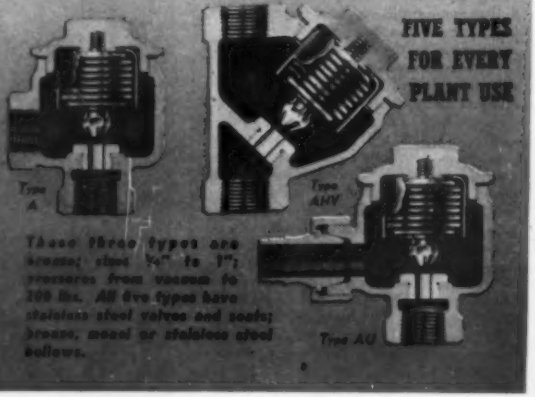
Now take the case of two traps with discharge valves of equal size and assume that they are operating at a given temperature difference.

The Nicholson "High Ratio" trap will open its valve wider and have larger capacity than the low ratio trap.

This is a reason why a Nicholson thermostatic trap operates faster and keeps a unit full of live steam. And, may we add, it's one of the advanced features that are influencing plant engineers increasingly to standardize on Nicholson.



The two types above are cast iron; sizes ½" to 2"; pressures from vacuum to 225 lbs. Type C also in cast steel for pressures to 300 lbs.



These three types are bronze; sizes ½" to 1"; pressures from vacuum to 200 lbs. All five types have stainless steel valves and seats; bronze, monel or stainless steel bellows.

Send for NICHOLSON TRAP CATALOG 250

Catalog 250 contains capacity tables, installation diagrams, and data, charts and formulas for determining the proper size trap.

W. H. NICHOLSON & CO.

207 OREGON ST., WILKES-BARRE, PA.

Sales and Engineering Offices in 53 Principal Cities

ARE YOU WORKING ON ANY PROBLEMS INVOLVING THE INSULATION OF PIPES? LET THIS HELPFUL FACT FINDER GIVE YOU . . .

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. . . Surface Temperature
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2 GREAT PIPE INSULATIONS

UNIBESTOS No. 750
—for temperatures up to 750° F.
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WRITE today, on your company letterhead, giving your title or function. A "Fact Finder" will be sent to you together with complete information on UNIBESTOS Pipe Insulations No. 750 and No. 1200.

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"B&W ALLMUL FIREBRICK *gives me twice the performance for my money!"*

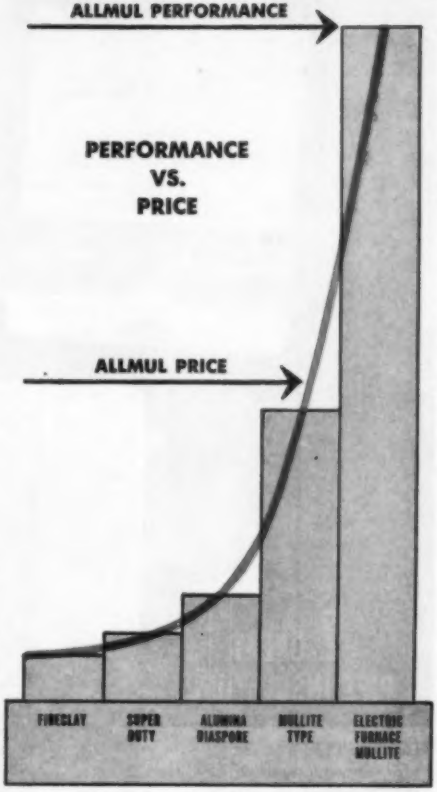
You, too, may discover new and truly important ways to save money with B&W ALLMUL—the new performance-proved, electric-fused mullite firebrick. B&W engineers have designed special mass production methods to produce this incomparable firebrick at a cost hitherto considered impossible. One result is the performance vs. price ratio charted at the right. And it's a big result, economically.

Another is a long list of Allmul repeat orders for the most severe service applications — ferrous and non-ferrous melting furnaces, slag melting furnaces, glass tanks, checker chambers, ceramic kilns and many others.

The properties described in the panel below explain why Allmul eliminates need for frequent furnace relining, cuts maintenance and saves valuable production time.

If you have not already investigated this remarkable new firebrick, we urge you to do so at once. The sooner you start using B&W Allmul, the greater your ultimate savings will be. SEND FOR NEW BULLETIN R-29.

ALLMUL is another important refractories development by B&W engineers who have continuously established new standards in industrial furnace refractories for the past 30 years.



CHECK THE PROPERTIES OF ALLMUL!

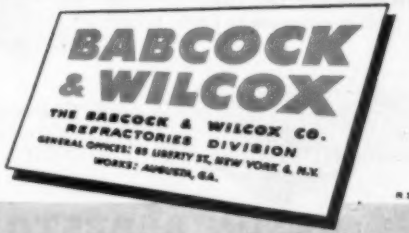
Here's how B&W Allmul stood up under standard tests.

SPALLING—12 cycles of heating to 2550F and chilling in cold air and water spray. **Result—no loss.**

HOT LOAD DEFORMATION—1½ hours at 3050F under load of 3600 pounds per square foot. **Result—less than 2% deformation.**

PERMANENT VOLUME CHANGE UNDER REHEATING—After 5 hours at 3200F. **Result—less than ½% change.**

FACT—no other firebrick in Allmul's price range can match its performance. **Fact**—no mullite brick at **any** price can better the performance of B&W Allmul.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R 594

B&W REFRACTORIES PRODUCTS — B&W 80 Firebrick • B&W Junior Firebrick • B&W 80 Glass Tank Blocks • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS—Stationary & Marine Boilers and Component Equipment... Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

DUCTILE IRON

A Revolutionary Metallurgical Development

DUCTILE IRON is a cast ferrous product which combines the *process advantages* of cast iron with many of the *product advantages* of cast steel.

No longer in the pilot-plant stage, this new material is now produced and sold on the basis of specifications. Not only are its individual properties exceptional, but no other common engineering material provides such a combination of excellent castability and fluidity, with high strength, toughness, wear resistance, and machinability.

Actually, "ductile iron" denotes not a *single* product, but rather a family of ferrous materials characterized by graphite in the form of spheroids . . . a form controlled, in a broad sense, by small amounts of magnesium. Presence of spheroidal rather than flake graphite gives this new product a ductility that is unique among gray cast irons.

Four important types of ductile iron now being produced commercially are tabulated below.

REPRESENTATIVE MECHANICAL PROPERTIES OF COMMERCIAL HEATS OF DUCTILE IRON

	Grade	Tensile strength, psi	Yield strength, psi	Elongation per cent	BHN	Usual condition
A	90-65-02	95/105000	70/75000	2.5/5.5	225/265	As-cast
B	80-60-05	85/95000	65/70000	5.5/10.0	195/225	As-cast*
C	60-45-15	65/75000	50/60000	17.0/23.0	140/180	Annealed
D	80-60-00	85/95000	65/75000	1.0/3.0	230/290	As-cast

A Pearlitic in structure. Provides good mechanical wear resistance.

B Pearlitic-ferritic in structure. Provides strength and toughness combined.

C A fully ferritic structure usually obtained by short anneal of either (A) or (B). Provides optimum machinability and maximum toughness.

D Higher phosphorous content than preceding grades, also higher manganese. Provides high strength and stiffness, but only moderate impact strength.

SOME UNIQUE PROPERTIES OF DUCTILE IRON

1. Its elastic modulus, about 25,000,000 psi, is virtually unaffected by composition or thickness . . .

2. It can provide a chilled, carbidic, abrasion-resistant surface supported by a tough ductile core. No other single material can combine these properties . . . its only counterpart being a tough material coated with a hard welded overlay.

3. As-cast ductile iron of 93,000 psi tensile strength has the same machinability rating as gray iron with a strength of 45,000 psi.

4. Annealed ductile iron can be machined at a rate 2 to 3 times that of good quality gray iron.

5. It can be satisfactorily welded.

APPLICATIONS

Automotive, agricultural implement, railroad and allied industries apply ductile iron, as-cast and heat treated, in components too numerous to detail.

Machinery, machine tools, crankshafts, pumps, compressors, valves and heavy industrial equipment such as rolls and rolling mill housings, utilize its high strength and rigidity.

In scores of engine, furnace and other parts serving at elevated temperatures, it provides oxidation and growth resistance heretofore unavailable in high carbon castings.

Other applications include paper, textile and electrical machinery, marine equipment, and pipe.

AVAILABILITY

Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing ductile cast iron under patent licenses. Request a list of available publications on ductile iron . . . mail the coupon now.

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TRADE MARK

The International Nickel Company, Inc.
Dept. PR, 67 Wall Street
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DUCTILE IRON

Name _____ Title _____

Company _____

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THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

DEMPSTER DUMPSTER
SYSTEM
SERVING
COST-MINDED
MANAGEMENT
FROM COAST TO COAST

. . . handling bulk materials of every description at phenomenal savings

Photos show the three simple stages of servicing a container. One man, the driver, and truck-mounted Dempster-Dumpster are constantly busy, picking up, hauling, and dumping one pre-loaded container after another. Dempster-Dumpster Containers range in capacity up to 12 cu. yds.

ESSO – recognized across the nation

Esso Standard Oil Company, well known for sound management, uses the Dempster-Dumpster System

Esso Standard Oil Company is among the hundreds of cost minded manufacturers, both large and small, using the Dempster-Dumpster System of bulk materials handling . . . the system recognized across the nation for its efficiency and ability to reduce costs.

The Dempster-Dumpster System of materials handling consists, basically, of one truck-mounted Dempster-Dumpster and any number of detachable Dempster-Dumpster Containers, which are spotted at convenient materials accumulation points inside and outside buildings. Containers are available in a wide variety of designs best suited to the type materials handled—be they bulky, light or heavy . . . solids, liquids, or dust . . . trash or rubbish.

The Dempster-Dumpster System reduces equipment together with investment and operation costs . . . eliminates standing idle time . . . eliminates re-handling of materials . . . and increases efficiency, sanitation and good "housekeeping." It will pay you to investigate the Dempster-Dumpster System now! A product of Dempster Brothers, Inc.

DEMPSTER BROTHERS, 551 Dempster Bldg., Knoxville 17, Tennessee

We have been asked:

"What is the best insulation for process lines which must be taken down for occasional cleanings?"

An engineer writes—"We have several hundred feet of process lines which must be taken down every few months for cleaning. These lines operate at a temperature of about 500° F. Which kind of pipe insulation do you recommend for this type of service?"

In this case, we suggested Bestfelt insulation for the lines.

This highly efficient pipe insulation is constructed of built-up layers of crimped asbestos papers having approximately 33 layers per inch of insulation thickness. This construction gives Bestfelt covering unusual strength and high resistance to breakage when the process lines are occasionally taken down and cleaned.

This insulation also is an excellent material for fabrication of flange or other fitting covers which must be removed and replaced frequently. In addition, it will withstand vibration better than other types of insulation recommended for use in its temperature range.

Bestfelt can be wired in place over the line, then covered with rosin-sized paper and sewed or pasted canvas. The insulation need not be removed each time lengths of pipe are taken down for cleaning.

Helping you arrive at the most practical solution to any insulation problem is part of the day-to-day job of Armstrong engineers. The next time you're up against a problem call in one of these men. Just get in touch with the Armstrong office nearest you.

SEND US YOUR QUESTIONS: If you have any questions on the use or application of either high- or low-temperature insulation, please do not hesitate to write to us. We'll do our best to give you a prompt and practical answer. Just address a letter or post card to Armstrong Cork Company, 7505 Maple Street, Lancaster, Pennsylvania.

ARMSTRONG'S INDUSTRIAL INSULATIONS

MATERIALS • INSTALLATION

FOR ALL TEMPERATURES FROM 300°F. BELOW ZERO TO 2300°F.

A Big Forward Step In The Measurement and Transmission of Flow

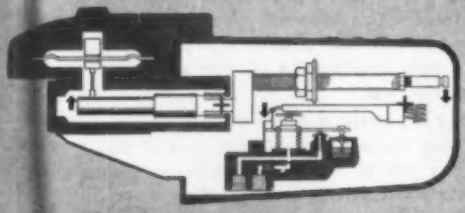
INTRODUCING *the New*

BROWN DIFFERENTIAL CONVERTER

(pneumatic-balance flow transmitter)

Easy Field Calibration –without water column

No Strainers Required



Functional schematic cross-section of the Brown Differential Converter . . . showing its utilization of the pneumatic-balance principle.

Easily Cleaned

Wide Rangeability –in one unit, 20 to 200" H_2O

Fast Speed of Response

Easy to Install

No Mercury or Seals

After long and rigorous testing in the field, the Brown Differential Converter is ready to set new high standards of simplicity and precision in the measurement and transmission of flow.

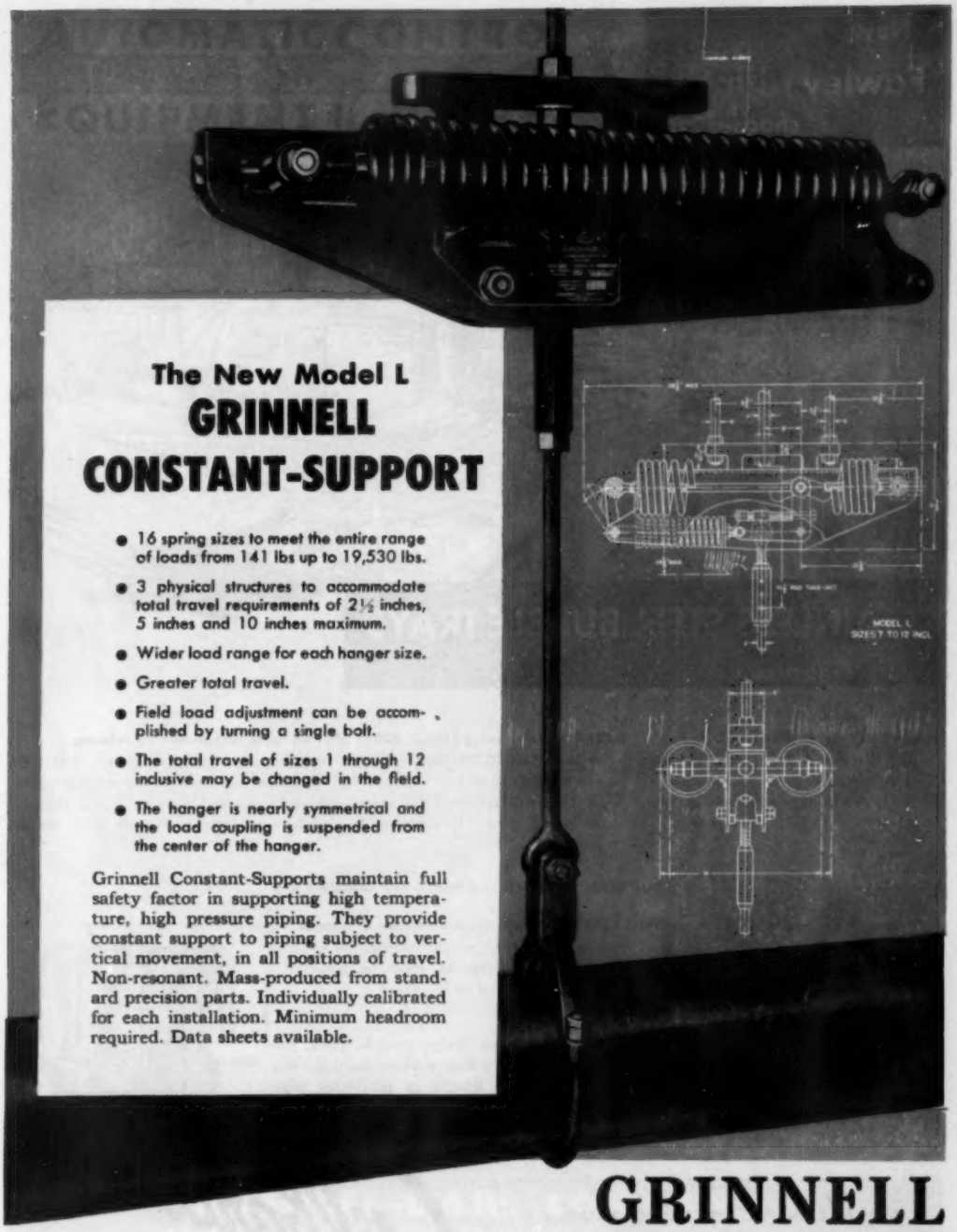
Operating on the pneumatic-balance principle, this compact and lightweight unit converts differential pressure at the orifice into a proportionate output air pressure which is a measure of flow. Range is continuously adjustable, from 0-20 to 0-200 inches of water. All adjustments are easily and simply made, without special tools or extra parts.

Applicable to a wide range of continuous processes, the Brown Differential Converter is the forerunner of an entirely new series of pace-setting developments made possible through Brown *Creative Instrumentation*. For detailed information write for a copy of new Catalog 2281 . . . and call in our local engineering representative for a discussion of your process needs. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, 4498 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS



The New Model L
GRINNELL
CONSTANT-SUPPORT

- 16 spring sizes to meet the entire range of loads from 141 lbs up to 19,530 lbs.
- 3 physical structures to accommodate total travel requirements of 2½ inches, 5 inches and 10 inches maximum.
- Wider load range for each hanger size.
- Greater total travel.
- Field load adjustment can be accomplished by turning a single bolt.
- The total travel of sizes 1 through 12 inclusive may be changed in the field.
- The hanger is nearly symmetrical and the load coupling is suspended from the center of the hanger.

Grinnell Constant-Supports maintain full safety factor in supporting high temperature, high pressure piping. They provide constant support to piping subject to vertical movement, in all positions of travel. Non-resonant. Mass-produced from standard precision parts. Individually calibrated for each installation. Minimum headroom required. Data sheets available.

MODEL L
SIZES 7 TO 12 INCL.

GRINNELL
WHENEVER PIPING IS INVOLVED

GRINNELL COMPANY, INC., Providence, R. I. Warehouses: Atlanta • Billings • Buffalo • Charlotte • Chicago
Cleveland • Cranston • Fresno • Kansas City • Houston • Long Beach • Los Angeles • Milwaukee • Minneapolis • New York
Oakland • Philadelphia • Pocatello • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane

New

Fawley refinery *chooses . . .*

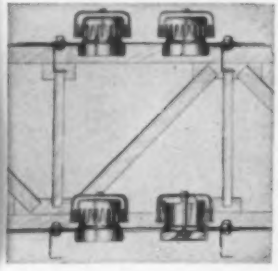
STAINLESS STEEL BUBBLE TRAYS

by Gilbarco

EUROPE'S LARGEST REFINERY—At Fawley, England, Gilbarco Bubble Trays will help make possible a daily crude oil processing capacity of more than 100,000 barrels.

GILBARCO'S new alloy BUBBLE TRAYS offer all these refinements for refining

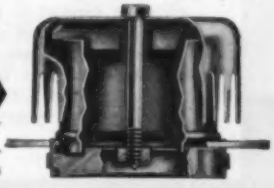
- **ADVANCED DESIGN**—Greater resistance to loading deflection. Increased accessibility to all tray levels. Greatly reduced joint leakage, minimum packing.
- **EASILY CLEANED**—Flush chimney mounting holes. One-man top-side removal of bubble caps. The inherent resistance to adhesion of smooth alloy metals.



"DUO-LEVEL" TRUSSES and IMPROVED BUBBLE CAPS

TWO TRAYS are supported by a common truss in the longer spans—means greater rigidity with lighter weight. Access for cleaning, inspection, or replacement is far easier.

BUBBLE CAPS—new design permits quick, easy removal by one man working from top side. There are no flanges or projecting edges around holes to slow up cleaning operations.



AVAILABLE IN ALL LIGHTWEIGHT METALS—Gilbarco with its large staff of experienced engineers stands ready to fulfill the needs of your process design.

Gilbarco

GILBERT & BARKER MFG. CO.

West Springfield, Mass.—Toronto, Canada
Established in 1865

AUTOMATIC CONTROL EQUIPMENT

ENGINEERED DESIGN BY **HAMMEL-DAHL**

SUNOCO®

QUALITY *thru* ACCURATE CONTROL *by* H-D®

This blending process at Sun Oil Company's new lube oil packaging plant at Marcus Hook Refinery, utilizes this battery of Hammel-Dahl Control Valves.

The versatility of this equipment permits production of a wide range of blends.

HAMMEL-DAHL COMPANY

243 RICHMOND STREET, PROVIDENCE 3, R. I., U.S.A.

ALBANY BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND DETROIT HOUSTON KALAMAZOO KANSAS CITY KINGSPORT, TENN. LOS ANGELES NEW ORLEANS NEW YORK PITTSBURGH SAN FRANCISCO. SEATTLE ST. LOUIS SYRACUSE TOLEDO TULSA WILMINGTON, DEL.

In Canada, Railway & Power Engineering Corporation, Ltd.

Service based on Production ... Cyanamid's plants at Ft. Worth, Texas, and Michigan City, Indiana, offer prompt service to all refining areas.

Service based on Research ... endless laboratory work helps develop catalysts suited to each refiner's needs.

Service based on Experience ... Cyanamid's knowledge of the refining industry forms the basis for sound judgment in helping customers solve their catalyst problems.

Cyanamid Service . . .

Cyanamid's technical service for the users of AEROCAT® Synthetic Fluid Cracking Catalysts is more than just files, reports, and slide rules. Much more. It represents a group of experts who are intimately acquainted with refinery operation and know fluid catalysts backwards and forwards.

With these men, it's what you *can't see* in their brief cases that's most important—knowledge, vision, and the ability to follow your problem through to its solution.

Backing this personal service is Cyanamid's long record of plant expansion and catalyst improvement to meet the petroleum industry's needs:

1942... Cyanamid starts production of synthetic fluid cracking catalysts at Ft. Worth to help refiners meet the demand for high octane fuel.

1946... Cyanamid expands Ft. Worth plant.

1946... Cyanamid becomes the *first* company to manufacture microspheroidal cracking catalysts on a commercial scale.

1948... Cyanamid expands production of MS catalyst at Ft. Worth in anticipation of growing demands.

1951... Cyanamid builds new MS plant at Michigan City, Indiana, as refining demands continue to grow.

Shortcut to "Cat" Cracking Efficiency

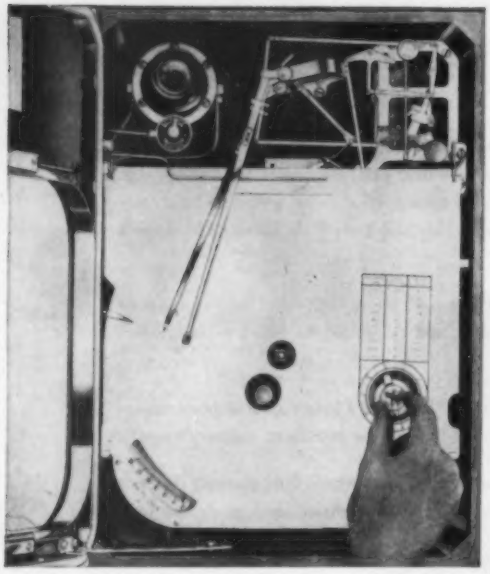
Vision, Experience, Facilities, Service... is the combination that enables Cyanamid to produce better chemicals for the petroleum industry: AEROLUBE® Additives for motor oils... AERO* Specialty Catalysts for chemical processes... Gasoline Dyes and Drilling Mud Chemicals. To learn more about these products and how they can help you...

send today for samples and literature.

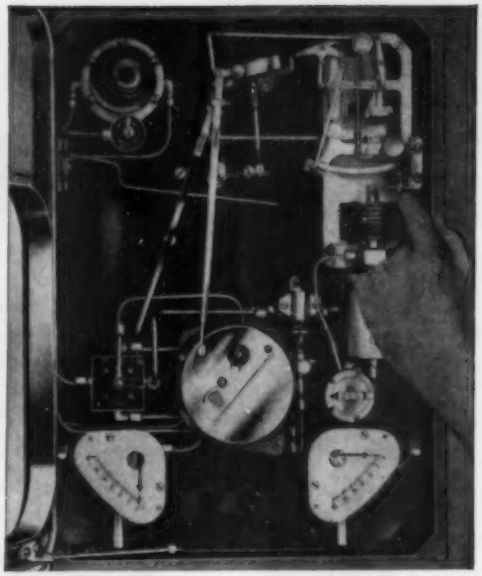
*Trade-mark

Catalyst
When ∧ Performance Counts...
Call on Cyanamid

AMERICAN *Cyanamid* COMPANY
PETROLEUM CHEMICALS DEPARTMENT, DIV. PT 5
30 Rockefeller Plaza, New York 20, N. Y.
In Canada: North American Cyanamid Limited, Toronto and Montreal



EASIEST TO PUT INTO OPERATION—Calibrated control actions save hours of shutdown. Reset, derivative and proportional values can be exactly reproduced at any time on the same or any other Series 500 controller . . . merely by duplicating the setting. Thus: controller adjustments can be standardized for any process throughout a plant or national organization.



EASIEST TO SERVICE—Inherently simple design, using the fewest possible parts, plus extremely close-tolerance manufacturing . . . make the instrument thoroughly interchangeable, trouble-free and a cinch to service. For example: only one simple adjustment puts the system in exact calibration even after complete disassembly and reassembly.

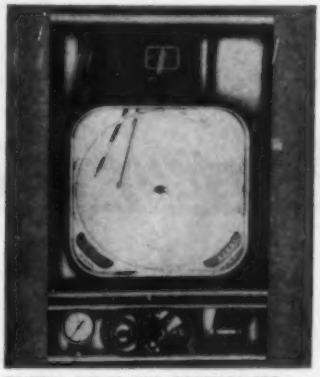
ONLY BRISTOL SERIES 500 CONTROLLERS GIVE YOU THIS EASE OF OPERATION

When you wish to reproduce a previous control action or duplicate one taking place at some other point, the Bristol Series 500 Air-Operated Controller permits you to do it merely by setting a dial.

Or, should the instrument require servicing, only one simple adjustment is needed to calibrate the control system and put it back in operation. Almost anyone can service this instrument.

Furthermore, users report that the Bristol Series 500 Controller requires practically no maintenance.

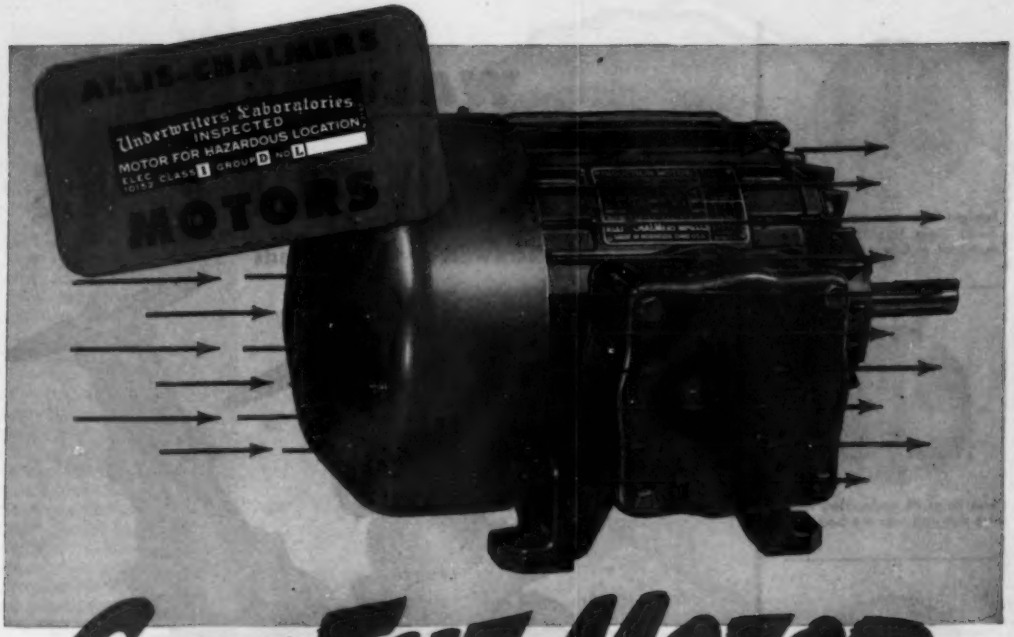
This outstanding instrument—a product of 60 years of experience—is completely described in Bulletin A120. THE BRISTOL COMPANY, 111 Bristol Road, Waterbury 20, Conn.



BRISTOL SERIES 500 CONTROLLERS are offered in five types—on-off, proportional, reset, derivative, reset plus derivative—to control temperature, flow, pressure, liquid level, humidity, pH. Conversion from one type to another can be made by the user. Model shown has external-manual station with mechanical interlock for test and service.

BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



GET THE MOTOR that Cleans Itself

DROP MOTOR MAINTENANCE COSTS to a new low by reducing motor cleaning operations. And this new Allis-Chalmers Type APZZ explosion-proof motor makes maintenance costs lower than ever before on this type of motor.

Here's Why

Concealed air passages have been eliminated; dirt cannot build up to cause overheating. Cooling air is blown over the ribbed cast iron frame and bearing housings carrying dirt away with it. How about oily dirt that sticks? It can be wiped or blown off without stopping the motor.

Rigid Construction

The frame is rigid cast iron which not only has high inherent corrosion resistance, but also holds bearings in alignment. Bearings are pre-lubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

The new Allis-Chalmers Type APZZ explosion-proof motor is built in all NEMA standard frame sizes from 224* to 505. Your A-C Authorized Dealer or District Office has complete information. Call today or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B6145.

A-3399

Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APKK, also available in frames 203 to 224 inclusive.

Straight-Flow Port Design reduces fluid turbulence to a practical minimum.

Seat Rings of end-seated type are screwed into the body.

Sure-Grip Malleable Handwheel for non-skid gripping even with heavy gloves.

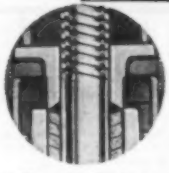
WALWORTH

iron body gate valves

with screwed or flanged ends

For complete information on these new Walworth Iron Body Valves, see your local Walworth distributor, or write for bulletin 106.

... 8 Outstanding Features



Brass Liner on Glands assures greater resistance to corrosion and scoring.

WALWORTH

valves and fittings

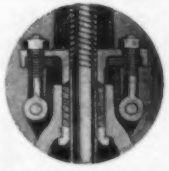
60 EAST 42nd STREET NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

T-head Disc-to-Stem connection on OS&Y types provides stronger connection, prevents loosening of disc by corrosion.

Bronze Back-Seat Bushings in bonnets of OS&Y valves.

Solid Web Type Disc in OS&Y valves for greater strength and longer service.



Hinged Gland Eye-Bolts on OS&Y valves permit faster, easier repacking under full pressure.

SERVICE LEDGER
1901-1951

- ANGLO-IRANIAN OIL CO. LTD.
- ARGENTINE GOVERNMENT OIL FIELDS
- ARGENTINE MINISTRY OF WAR
- ATLANTIC REFINING CO.
- ATOMIC ENERGY COMMISSION
- BRITISH AMERICAN OIL CO. LTD.
- CANADIAN OIL REFINERIES, LTD.
- CALIFORNIA REFINING CO.
- CHAMPLIN REFINING CO.
- CIE. DE RAFFINAGE SHELL-BERRE
- CIE. FRANCAISE DE RAFFINAGE
- CIE. INDUSTRIELLE DES PETROLES
- CITIES SERVICE OIL CO.
- CITIES SERVICE REFINING CORP.
- COLGATE-PALMOLIVE-PEET
- CONSOLIDATED REFINERIES, LTD.
- CONTINENTAL OIL CO.
- CORY BROTHERS & CO., LTD.
- CREOLE PETROLEUM CORP.
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- EL DORADO REFINING CO.
- ESSO STANDARD OIL CO.
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- GLOBE OIL & REFINING CO.
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- HUMBLE OIL & REFINING CO.
- IMPERIAL CHEMICAL INDUSTRIES
- IMPERIAL OIL LTD.
- KANOTEX REFINING CO.
- KENDALL REFINING CO.
- LEVER BROS.
- LION OIL CO.
- MAGNOLIA PETROLEUM CO.
- MARINE OIL REFINERS OF AFRICA, LTD.
- MATHIESON CHEMICAL CORP.
- McCOLL-FRONTENAC OIL CO., LTD.
- MID-CONTINENT PETROLEUM CORP.
- MITSUBISHI OIL CO., LTD.
- NATIONAL PETROLEUM COUNCIL OF BRAZIL
- PAN AMERICAN REFINING CORP.
- PENNZOIL CO.
- PHILLIPS PETROLEUM CO.
- POLYMER CORP., LTD.
- PURE OIL CO.
- SHELL CHEMICAL CORP.
- SHELL OIL CO.
- SHERWIN-WILLIAMS CO.
- SINCLAIR REFINING CO.
- SKELLY OIL CO.
- SOCIETE DES RAFFINERIES DE PETROLE DE LA GIRONDE
- SOCIETE GENERALE DES HUILES DE PETROLE
- SOCIETE INDUSTRIELLE BELGE DES PETROLES
- SOCONY-VACUUM FRANCAISE
- SOCONY-VACUUM OIL CO.
- E. R. SQUIBB & SONS
- STANDARD OIL CO. (INDIANA)
- STANDARD OIL CO. (OHIO)
- STANDARD OIL CO. OF CALIFORNIA
- SWIFT AND CO.
- TEXAS CO.
- UNION OIL CO. OF CALIFORNIA
- UTAH OIL REFINING CO.
- WASATCH OIL CO.
- WOOD RIVER OIL & REFINING CO.

Avgas, rubber and anti-freeze in the raw . . . for Shell!

In 1942, Kellogg underwent its first domestic process and construction work for Shell—three Fluid catalytic crackers simultaneously—two for Wood River, Illinois, and one for Dominguez, California.

This was "matched" by an assignment to build a government-owned butadiene plant—according to designs furnished by Shell Chemical, the ultimate operator—in California. During the following years, Kellogg designed and constructed deasphalting and phenol treating units for lubricating oil production in this country. In the early thirties thermal cracking facilities were constructed in France for Shell's associate, Compagnie de Raffinage Shell-Berre.

Most recently, Kellogg has built major units for the production of ethyl chloride and for processing hexylene glycol from diacetone alcohol at the new Houston Deer Park plant of Shell Chemical.

THE M. W. KELLOGG COMPANY

A SUBSIDIARY OF PULLMAN INCORPORATED

for fifty years an integral part of processing history

NEW YORK JERSEY CITY LOS ANGELES TULSA HOUSTON TORONTO LONDON PARIS

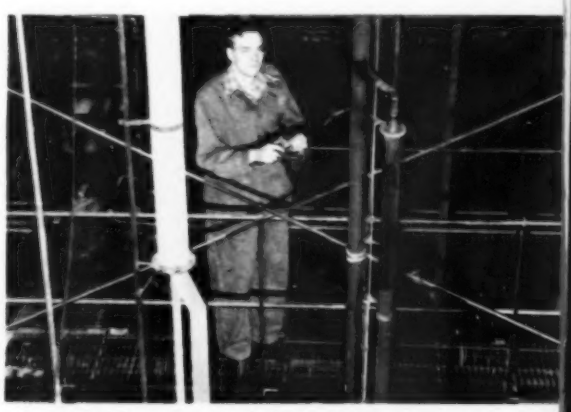
Portrait at

This year is Kellogg's fiftieth of service to industry. At this time naturally, as a group of men—known collectively to the modern business world as The M. W. Kellogg Company—we can think back nostalgically. We can remember the chimney stacks

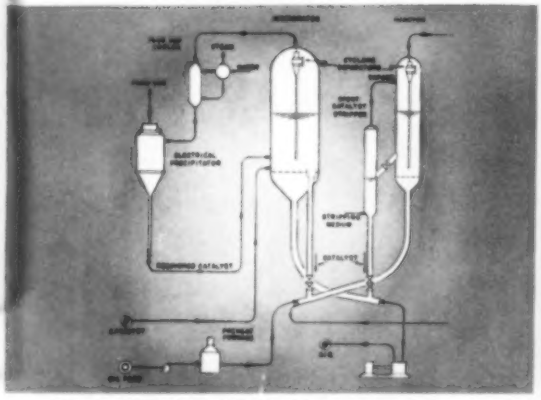
"Harnessing the Specialties..."

In previous issues of this magazine, camera "portraits" of M. W. Kellogg today have highlighted the major aspects of Kellogg's widely diversified chemical, process, metallurgical and equipment development program.

This month, development work in the specialty of chemical engineering leads logically to the introduction of the fountainhead of Kellogg's service to industry—Process Engineering.



1. *FROM THE BROAD CANVAS* of Kellogg development activity, let us turn to the specifics of chemical processing—starting with the *Chemical Engineering Development Group*. The chemical unit processes and operations are its responsibility, including heat exchange, solvent separation, diffusion and the action of fluidized solids (pictured)—the latter vital to modern refinery processing.



4. *BUT ALL THIS DEVELOPMENT* work has only one end purpose: More efficient processing plants, achieved either through improved processes or improved process equipment. Thus *Process Engineering* is truly the fountainhead through which Kellogg serves industry. The Process Engineering Department is made up of men of varied talents, varied experience and varied functions.

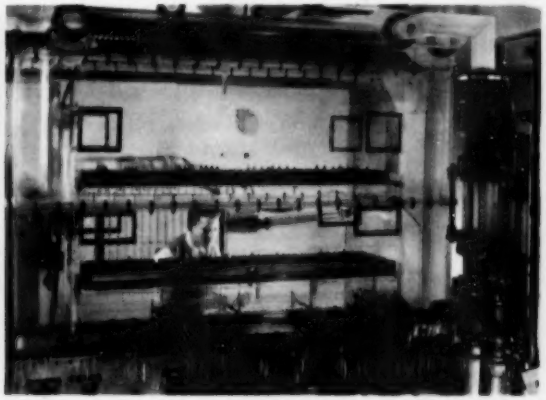
5. *FIRST TO CONTACT* any customer are those engineers charged with creating the optimum process sequence—combinations of two or more processes—to accomplish a desired industrial task. Thus, they work continually with dollars-and-cents as well as throughput, stream efficiency and product quality. These process specialists are supported in this work by a sizeable *Economics Group* which is an integral part of the department.

Fifty... no 4

KELLOGG
M W
1901-1951
50th Anniversary

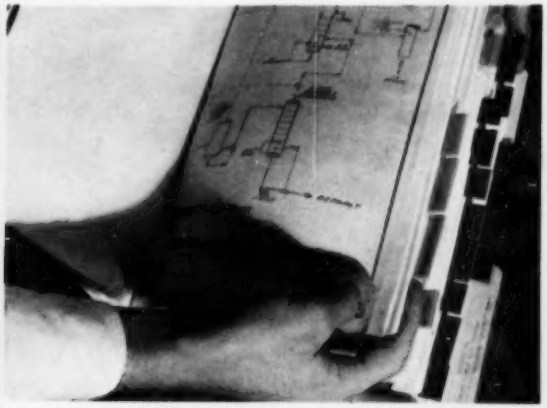
we built in 1901 . . . the first crude vessels for oil refiners in the 'teens . . . our first combination unit. The forty-odd Fluid cat crackers built in these years. But, after all, The M. W. Kellogg Company is only a factor as it is able to serve industry today. For that reason, we are presenting this series of monthly camera studies which document our belief that a truly integrated organization can better serve industry to achieve greater earning power. This is No. 4 in the series.

2. *THIS DEVELOPMENT GROUP* produces such volumes as the one pictured above. Some four inches thick, it documents three years' development effort by Chemical Engineering in the field of heat exchange alone, which has resulted in improved design of Kellogg heat exchangers. Similarly, the group has worked out liquid-vapor equilibrium constants for hydrocarbon mixtures under all manner of conditions.



3. *ANOTHER VALUABLE CONTINUING STUDY* by the chemical development engineers concerns the "fluidynamics" of fractionating towers, pointing toward more efficient bubble towers of all types. These studies are constantly contributing to increased tower efficiency and may soon be responsible for the design of smaller bubble towers with as great or even greater throughput than the ones in current use.

6. *THIS ECONOMICS GROUP* carries on general industry studies as well as individual studies of specific projects. Much of the stimulation of the development people for new processes comes from this group who constantly strive to perform processing functions at lower operating costs with smaller initial investments . . . and to obtain simultaneously improved yield and quality of products.



7. *BACK OF THESE* two groups are the *Process-Unit Engineers*—each group specializing in a particular process or type of processing. These engineers "live" with their particular process, devote their entire time to its improvement. These are the engineers who prepare for all Kellogg projects, the detailed process designs, flowsheets, etc., which are incorporated into Process Data Books, like the one shown here.

NEXT MONTH

. . . in the fifth in this series of camera studies of M. W. Kellogg today . . . you will see how Kellogg handles "Details by the Million" in the important phase of Design Engineering.

Weld'd to take processing punishment...

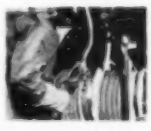
M. W. KELLOGG

For catalyst lines a man can walk through . . . for process piping that will exclude a mouse, Kellogg's exclusive fabricating techniques — bending, welding and stress relieving — produce piping that has appreciably longer service life in punishing process applications.

Pressure Vessels
Vacuum Vessels
Fractionating Columns
Drums and Shells
Heat Exchangers
Process Piping
Hi-pressure—Hi-temp Power Piping
Bends and Headers
Giant One-Piece Bends
Forged and Welded Fittings
Radial Brick Chimneys

Special Studies of unusual problems such as stress corrosion and graphitization to assure long life and low maintenance.

Exclusive Equipment for accurately analyzing stresses in piping and providing unique data for critical installations.



Top Welding Performance in shops and in the field by welders accustomed to working under X-ray checks.

Metallurgical Research by recognized specialists who have made major contributions in this field.

Complete Facilities for the fabrication of steel products from simple forgings to specially cast bimetallic devices.

Quality Control, devised by metallurgical experts, embracing forming, heat treating and non-destructive testing.

NEWS FOR OPERATORS IN WESTERN CANADA!

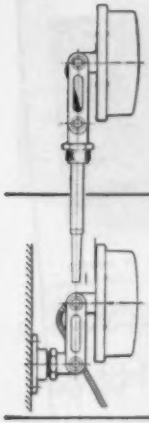
Canadian Kellogg Company has established complete shop facilities for the fabrication of all types of piping at EDMONTON in Alberta Province. Inquire directly or through any Kellogg office.

The M. W. Kellogg Company *(A Subsidiary of Pullman Incorporated)* **New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris**

PALMER

mercury actuated Dial Thermometers

now in three types to suit any requirements

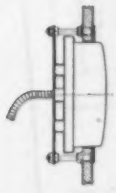


1 Rigid Stem Dial Thermometer

Rigid stem tapered bulb, interchangeable with standard industrial thermometer separable socket.

2 Wall Mounted Dial Thermometer

Wall mounted dial thermometer with flexible connecting armor. Case adjustable to easy reading position.



3 Flush Mounted Dial Thermometer

Flush mounted style for panel mounting with flexible connecting armor.

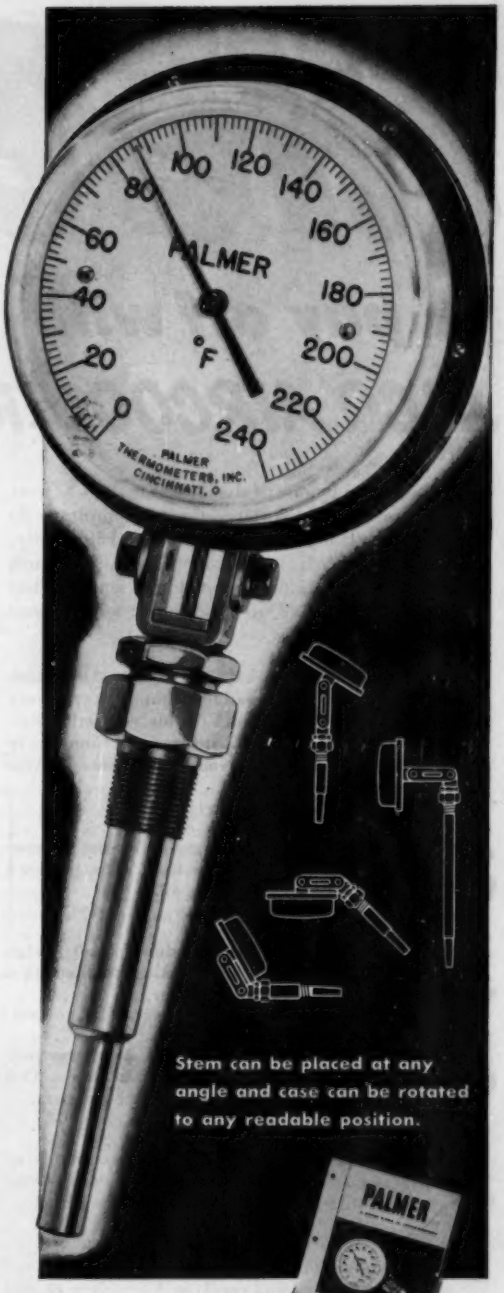
All three types have a full 4½" dial Face

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensation. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.



Stem can be placed at any angle and case can be rotated to any readable position.

SEND FOR THIS BULLETIN

For details on the New Palmer Dial Thermometer, please write for Palmer Bulletin 51-129.

PALMER THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2515 NORWOOD AVE., CINCINNATI 12, O.

THE BIG 5

pay off with ALCO AIRCOOLERS

Pioneered by one of the largest makers of heat exchangers, Alco **Aircoolers** are built to do just one thing and do it right—cool efficiently. To accomplish this, Alco engineers have built into every Alco **Aircooler** design features that give you *all* five of these major advantages:

1 ***Low Cost***—goes way beyond first cost. Alco standardized parts . . . broad heat-transfer experience . . . volume production . . . plus correctly engineered safety factors . . . insure *real* economies in installation, operation and maintenance of Alco **Aircoolers.**

2 ***Flexible Design***—You can get either the radiator core or fintube type cooler from Alco, powered by electricity, steam, gas or oil.

3 ***Efficient Performance*** — Induced draft design eliminates the chance of recycling hot air with a subsequent loss in heat transfer.

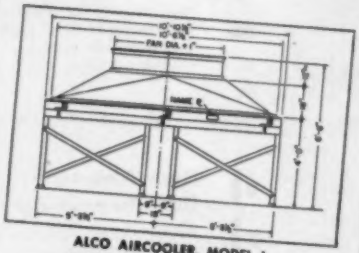
4 ***Easy Maintenance***—Fewer parts, easy accessibility and better wearing characteristics make Alco **Aircoolers** a favorite with maintenance men.

5 ***Quick Installation***—For fast field assembly, every part is marked and identified on assembly drawings so that no specialized labor is required.

Why not put the big 5 to work in your plant? Send for the free catalog on Alco **Aircoolers** *or call your nearest Alco Sales Engineer at Chicago, Cleveland, Houston, Kansas City, Los Angeles, New York or Tulsa. Plants at Dunkirk, N. Y. and Beaumont, Texas.*

ONE AIRCOOLER FROM THE ALCO LINE

Hundreds of Alco Aircoolers are in service cooling jacket-water, gas, engine-lube oils, vapors, etc.



ALCO AIRCOOLER, MODEL I
CONDENSED SPECIFICATIONS

No. radiators—Four 6-ft. nominal length.

Fans—5 or 6 ft. dia.—2, 4 or 6 blade—adjustable or fixed pitch.

Drive—Direct, Electric Motor (V-belt or Gear Drive can be furnished on request).

Surface External—2,720 sq. ft. Style T-5 (Water Core)—2,611 sq. ft. Style T-1 (Oil Core).

Surface Internal—450 sq. ft. Style T-5—347 sq. ft. Style T-1.

Face Area—46.4 sq. ft.

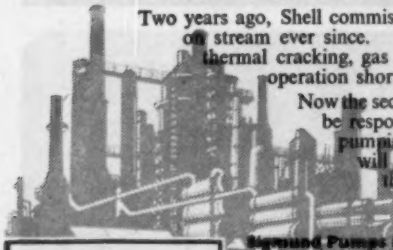
ALCO
ALCO Products Division
AMERICAN LOCOMOTIVE COMPANY

In step with tomorrow—**ALCO AIRCOOLERS, Heat Exchangers, Evaporators, Feed Water Heaters, Pressure Vessels, Pipe**

Shell Repeat Order for Sigmund Pumps!

Process Pump Output -over 20,000 H.P.

BIGGEST PROCESS PUMP INSTALLATION EVER DESIGNED AND MADE IN BRITAIN



Two years ago, Shell commissioned the first distillation unit at Cardon, Venezuela and it has been on stream ever since. The process pumps operating in this distiller—along with units for thermal cracking, gas tail, high vacuum and other sections of the refinery, which went into operation shortly afterwards, were supplied by Sigmunds.

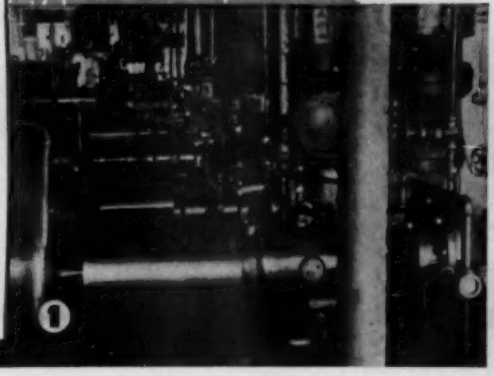
Now the second distillation unit has been put in hand, and once more Sigmund are to be responsible for the pumps. This new contract raises the total of Sigmund pumping equipment at the Cardon refinery to over 20,000 h.p., in a plant which will have an intake of crude oil in the region of 140,000 barrels a day when the additional distillation unit is completed—sufficient to provide over a third of Britain's requirements of petroleum products.

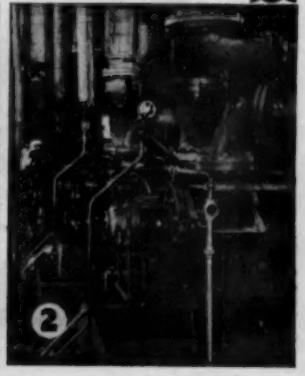
Sigmund Pumps Ltd., Terminal House, 52, Grosvenor Gardens, London, S.W.1.

The process pumps—some of them for operating temperatures of 900°F—others made in 18.8.3. stainless steel, are typical products of the Sigmund organization. Designed and engineered in one of the finest pump plants in the world, and, like all Sigmund pumps, built to give real service.

1. Group of single stage slurry pumps type HO-N in catalytic cracking unit.

2. Group of hot oil pumps of a total output of 3,000 H.P.

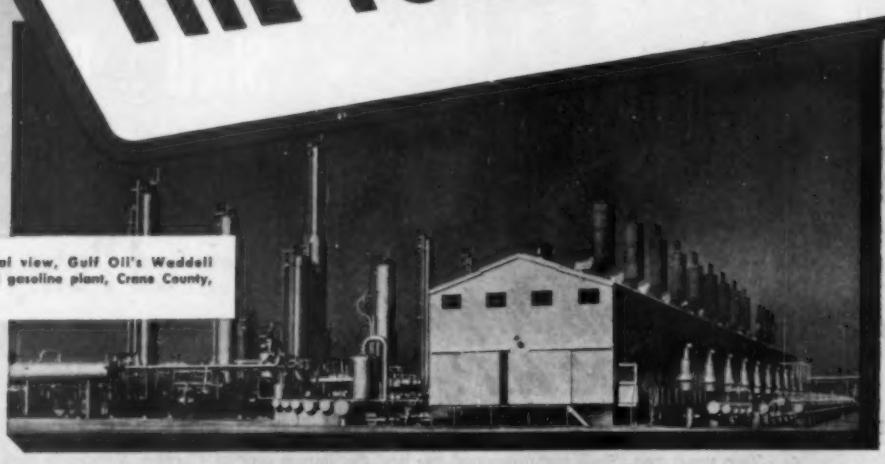




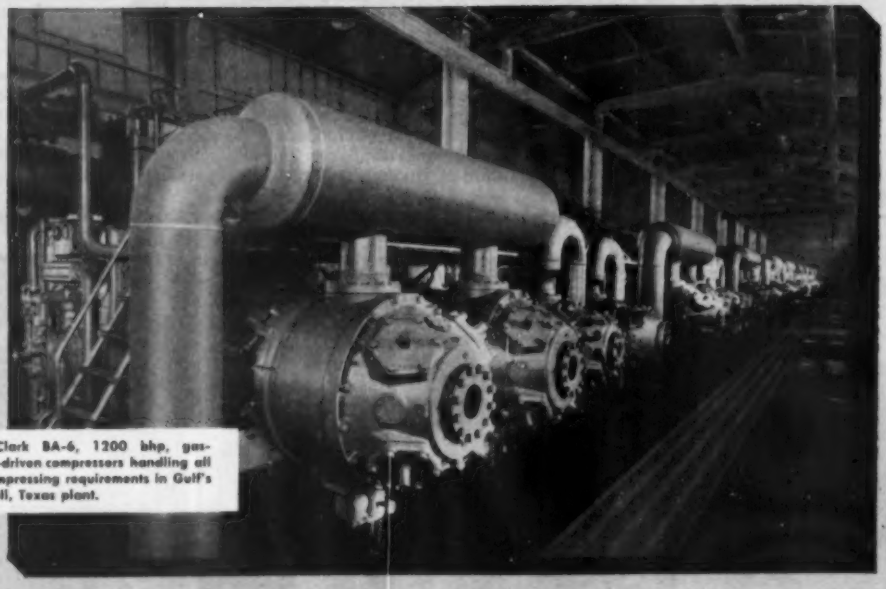
S.P.4

New York address: 30 Church St., 7, N. Y. Tel.: Worth 4-3396

THE TOUGH ONES.



General view, Gulf Oil's Waddell natural gasoline plant, Crane County, Texas.



Nine Clark BA-6, 1200 bhp, gas-engine-driven compressors handling all gas compressing requirements in Gulf's Waddell, Texas plant.

. . . Invariably GO TO CLARK!

For compressing 40,000,000 cu. ft. of gas per day under difficult conditions at Gulf Oil's Waddell, Texas plant, Clark Compressors were given the job

Compressing 40,000,000 cu. ft. of raw gas per day from 20 psig. suction to 600 psig. discharge pressure is a man-sized assignment under *any* circumstances. But, at Gulf Oil Corporation's Waddell gasoline plant, conditions present a *real challenge* . . . a particularly tough one . . . and Clark Compressors were given the job!

For here, in Crane County, Texas, Gulf is working with a two percent hydrogen sulfide gas. And Gulf is drawing this gas (containing 980 lbs. of water vapor per million cu. ft.) from seven different fields . . . a condition which naturally involves considerable variation in the composition of the stream and is bound to affect the constancy of operating results.

So, as one would expect, a complex problem was faced in meeting the three-compression-stage requirements. But the fact that Gulf is experiencing highly satisfactory performance from Clark Compressors in other installations . . . the fact that Clark "Big Angles" are widely known for their great flexibility of compressor cylinder staging — their smooth, flexible operation under varying pressure conditions — their super power and compactness that effect savings in building, foundation and maintenance — *all played a part in Gulf's decision to go to Clark!* Nine Clark 2-cycle, BA-6, gas-engine-driven compressors, 1200 bhp each, are doing the job with eminent success.

Complete data and literature on Clark Compressors are obtainable from your nearest Clark representative.

SEE the difference in

CLARK COMPRESSORS

CLARK BROS. CO., INC. *One of the Dresser Industries* **OLEAN, N. Y.**

New York • Tulsa • Houston • Chicago • Boston • Washington • Los Angeles • Birmingham • Detroit • Salt Lake City • San Francisco
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On thousands of applications in every field of manufacture, stepless variable speed operation assures exactly the right speed for every operation . . . for every operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation pays off in higher rates of production, a more uniform better quality product and more efficient performance of your equipment and your operators.

Master Speedrangers provide this infinitely variable speed in an all-metal, mechanical variable speed unit whose compactness and durability are extra features which help you make a good job better. And nowhere else will you find variable speed drives that are so flexible, so easily adaptable and in such a wide range of types and sizes.

makes a good job better

For example, look at the plastic forming machine shown below. The Speedranger, on the drive unit incorporates an electric motor, a variable speed unit and a gear reduction . . . all standard Master units that easily combine into one compact, integral power package. This provides exactly the right speed, the right features, in a unit that you can mount right where you want it.

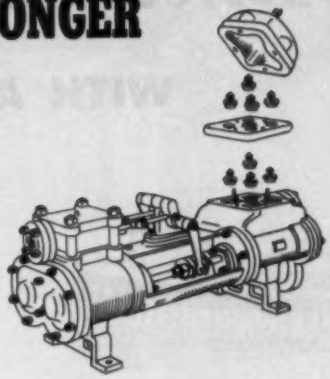
Probably you will not need this same combination of features. However, the next time you need a drive for material processing, handling, and conveying equipment; mixers and agitators; welding-positioners; machine tool drives; testing and calibrating equipment . . . to name only a few . . . see what a really remarkable job Master Speedrangers can do for you. Write for Data 7525, new twenty-four page booklet on Speedrangers.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

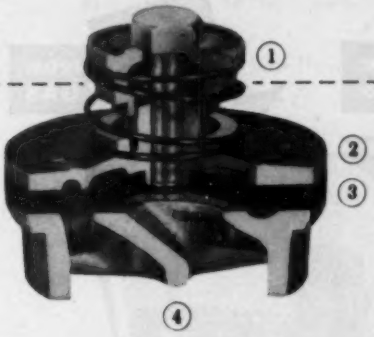
especially when you use

MASTER SPEEDRANGERS

4 WAYS TO REDUCE PUMP MAINTENANCE
KEEP PUMPS IN SERVICE LONGER



1. **Prevent STEM and SPRING breakage.** Exclusive double shock absorber built into Sims valves stops impact shock.
2. **Stop wear.** Long guide of ROTATOR prevents cocking of DISC—assures even opening.
3. **Keep seating surfaces leak free.** Only Sims guarantees the valve DISC will rotate every time it lifts.
4. **Stop valve slam and knock.** Quiet operation is gained by cushioning moving parts and cutting resistance to flow through the SEAT . . . with patented **inclined ribs.** This reduction of resistance allows cylinders to fill completely. Pump capacity is increased 20%.

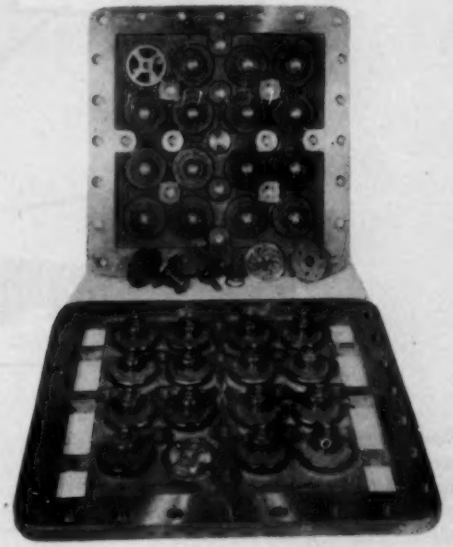


Sims Valves to fit your pumps.

Sims valves are available in sizes 2¾" to 15¼" and all types—screwed, pressed, etc. and in decks—to fit all makes of reciprocating pumps. Illustration at right shows medium-size decks of popular type for refinery pumps. Another popular size is the 48" square deck with 48-4½" Sims Inclined Port Rotating Pump Valves.

The materials and workmanship of Sims valves and decks stand up under difficult pumping conditions.

We are geared to give you rapid delivery to meet essential refinery requirements.



Sims valve decks for a 12 x 10 x 18 pump 16-4 inch long-service Sims valves in each.

New catalog shows how Sims valves fit any pump—how they work—efficiency and comparison charts. Send for your free copy today.

SIMS PUMP VALVE CO., INC.

145 Hudson Street, New York 13, N. Y. **M & M Building, Houston, Texas**

Make H_2SO_4 from H_2S

WITH A CHEMICO PLANT

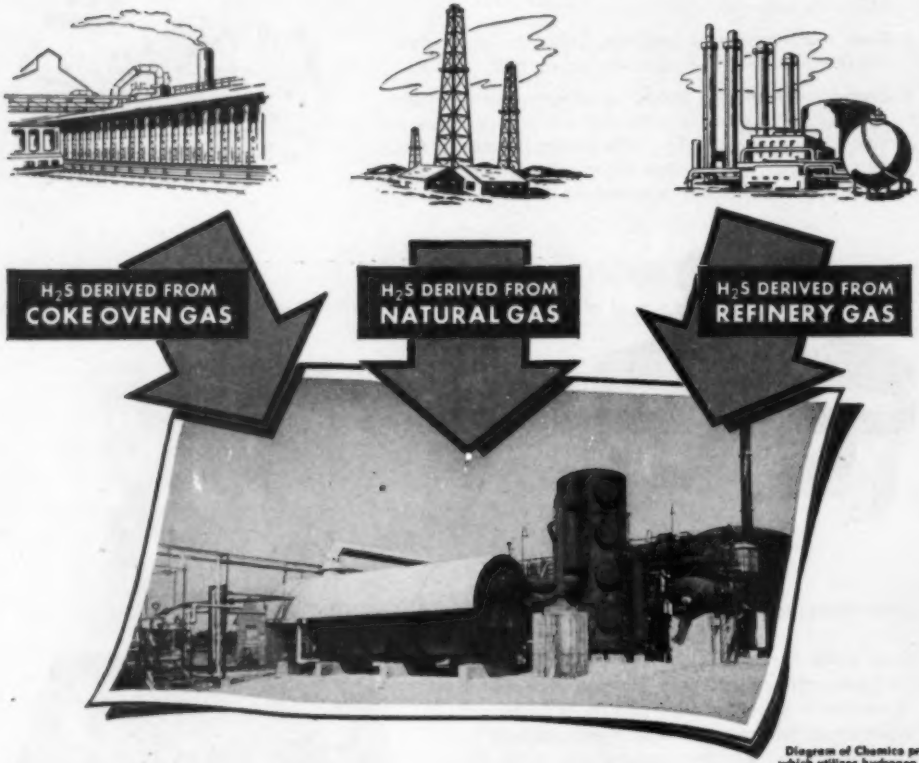
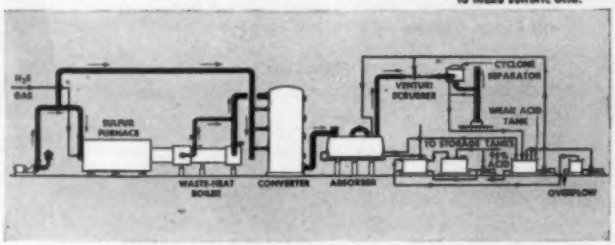


Diagram of Chemico process which utilizes hydrogen sulfide to make sulfuric acid.

Now that raw sulfur is in short supply, it has become necessary to manufacture sulfuric acid from other raw materials such as hydrogen sulfide. If you have hydrogen sulfide available, it will pay you to investigate Chemico's practical and proven process for making H_2SO_4 from H_2S. Chemico's new type sulfuric acid plant is especially well suited for this purpose. Or existing sulfuric acid plants can be converted.



CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

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EUROPEAN TECHNICAL REPRESENTATIVE: CYANAMID PRODUCTS, LTD., LONDON W. C. 2, ENGLAND
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Chemico plants are profitable investments

You can't go WRONG!

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When you install Powell Valves according to Powell recommendations, you can be sure that you have the right valves to meet the actual service conditions

There's always a Powell Valve—correct in design and materials—for every flow control service.

Quality line throughout "The Line"

Fig. 1503—Class 150-pound, flanged end, Cast Steel O. S. & Y. Gate Valve.

POWELL

The WM. POWELL CO., 2525 Spring Grove Ave., P. O. Box 106, Station B, Cincinnati 22, Ohio

WHEN STORING FLAMMABLE LIQUIDS

IT PAYS TO BE

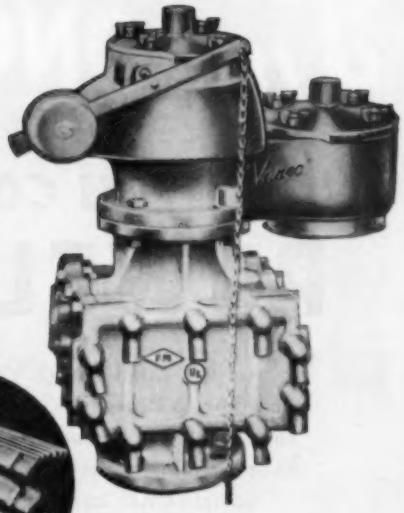
EXTRA **Safe**

WITH "Varec"

FLAME ARRESTERS

in combination with your

VENT VALVES



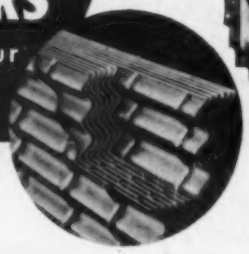


Fig. No. 5800A Conservation Vent unit consisting of "VAREC" Vent Valve in combination with VAREC Flame Arrester

The belief that conservation vents or breather valves alone will prevent travel of flame back into flammable liquid storage tanks is questionable because of the many contributing factors. Careful authoritative analysis reveals that valves by themselves do provide *some protection* but this "*protection*" *is by no means adequate* under all circumstances.

Safety authorities emphatically advise that "vent valves are not regarded as providing the required protection against fire and explosion." A textbook on safety states that "a conservative policy is to provide flame arresters in conjunction with other vent equipment on all cone-roof atmospheric tanks handling oils with a flash point up to 200° F. open cup."

"VAREC" Flame Arresters when used as a unit with "VAREC" Vent Valves give you full fire protection at extremely low cost. Average installations run approximately .1 of 1% of your investment in tank and products. Consult your nearest "VAREC" representative or write for further information.

P-16

THE VAPOR RECOVERY SYSTEMS COMPANY
COMPTON, CALIFORNIA, U. S. A.
Cable Address: VAREC COMPTON USA (All Codes)
New York — Boston — Pittsburgh — Chicago — Detroit — St. Louis — Houston
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PROVED and APPROVED "Varec"

IN YOUR PRODUCT DEVELOPMENT—

You Need a Good Man on the *Other End, Too!*

Product development programs are no longer "one-company" jobs. The bigger your program is, the more you have to rely on the other fellow—and the output of *his* research —to make your own succeed.

Through its continuing development work on both basic and new industrial chemicals, General Chemical can help you "man the saw" in many ways:

For example, General's research has introduced a number of important new industrial chemicals. Some have proved the basis for customers' development programs or the answer to their development problems. Among these helpful "tools" are:

BORON TRIFLUORIDE AND COMPLEXES, *versatile fluorine catalysts for organic reactions;* SULFUR HEXAFLUORIDE, *remarkable new gaseous dielectric;* GENETRONS*, *aliphatic fluorine compounds; and* SULFAN*, *stabilized sulfuric anhydride for sulfonations.*

For special process requirements, you may find General's ability to produce commercial quantities of "custom-made" chemicals equally valuable to you.

These are but some of the services our product development program offers. A personal discussion of your problems may suggest other ways it can "team up" with yours. Let's review them.

* Reg. U. S. Pat. Off.

BASIC CHEMICALS FOR AMERICAN INDUSTRY

GENERAL CHEMICAL DIVISION

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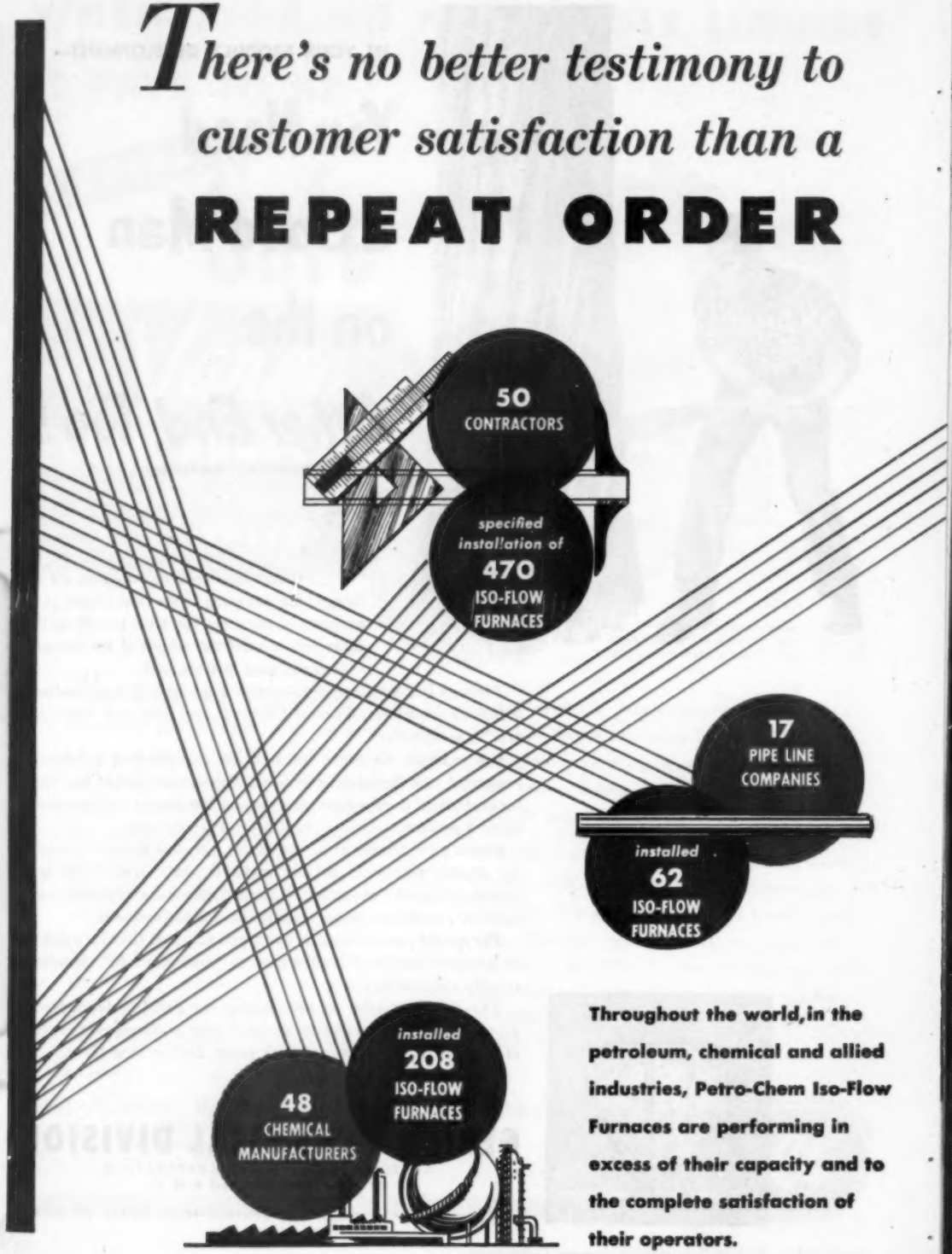
40 Rector Street, New York 6, N. Y.

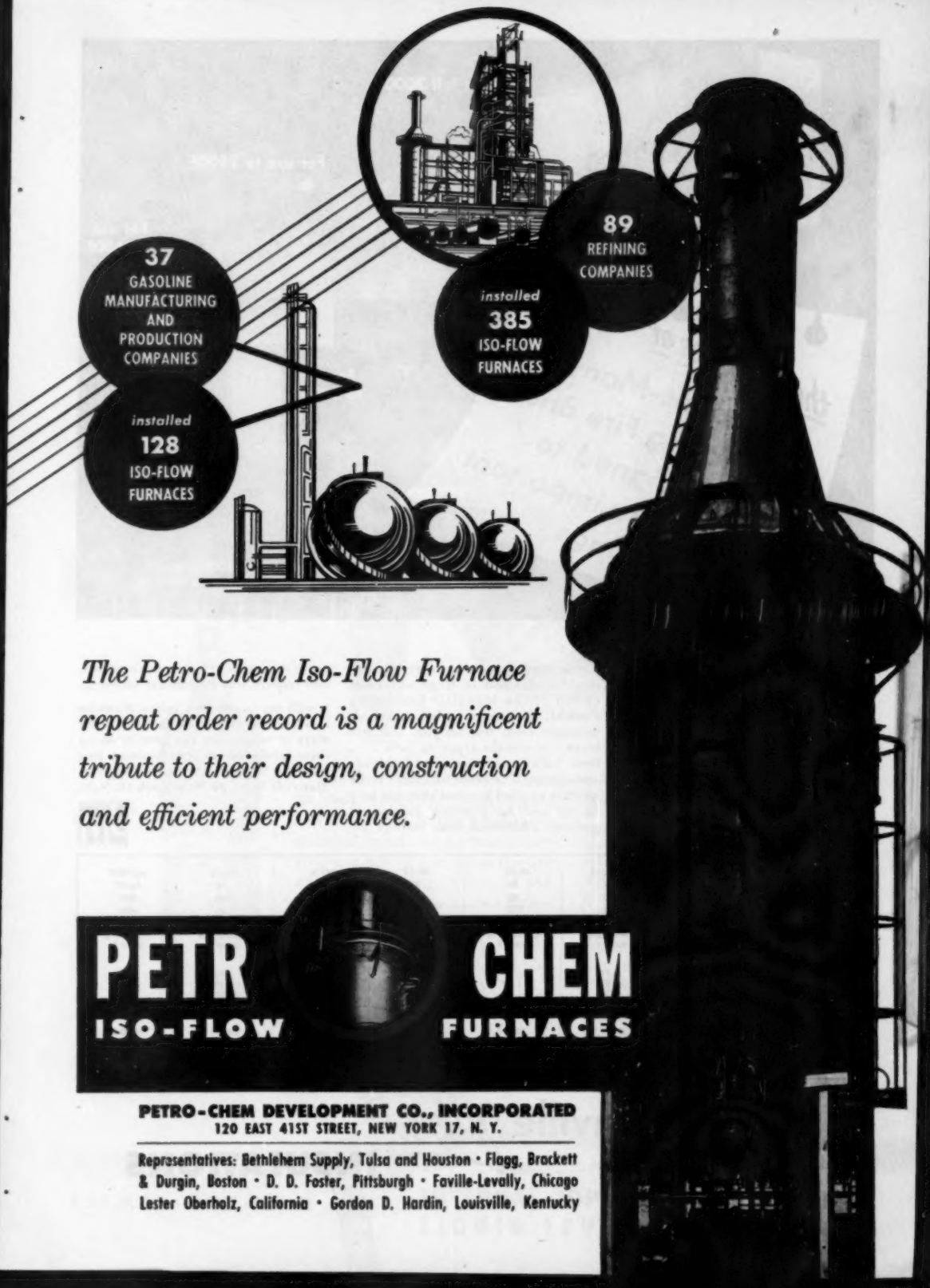
OFFICES IN MAJOR INDUSTRIAL CENTERS FROM COAST TO COAST

There's no better testimony to customer satisfaction than a

REPEAT ORDER



Throughout the world, in the petroleum, chemical and allied industries, Petro-Chem Iso-Flow Furnaces are performing in excess of their capacity and to the complete satisfaction of their operators.



The Petro-Chem Iso-Flow Furnace repeat order record is a magnificent tribute to their design, construction and efficient performance.

PETR CHEM
ISO-FLOW FURNACES

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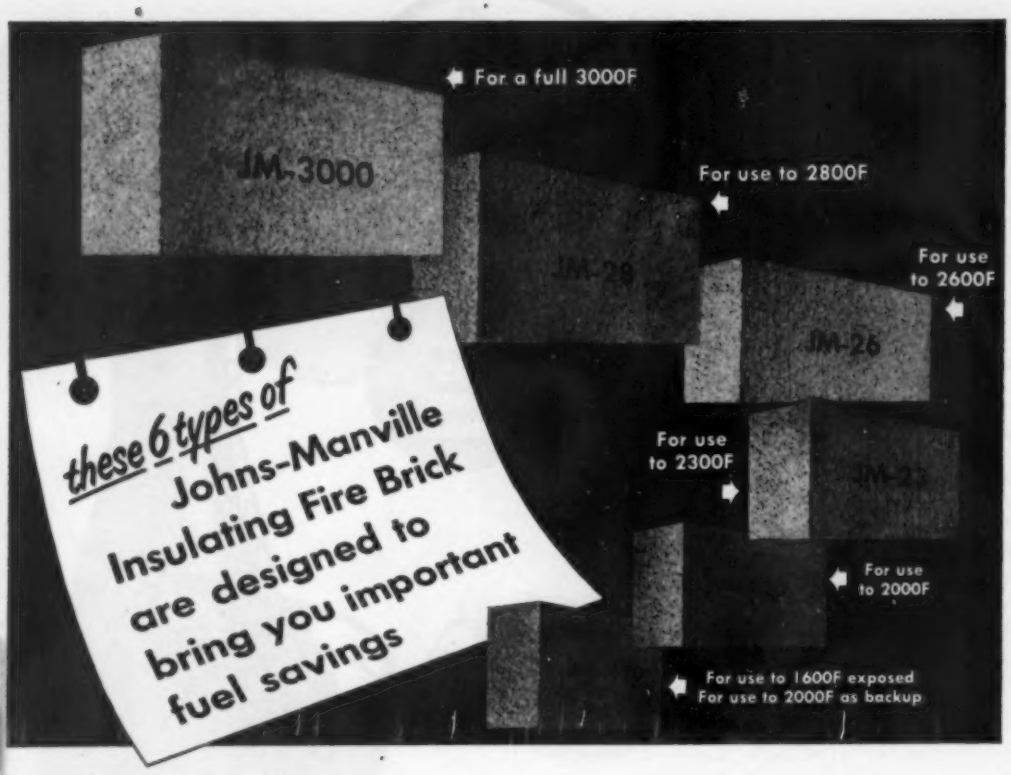
120 EAST 41ST STREET, NEW YORK 17, N. Y.

Representatives: Bethlehem Supply, Tulsa and Houston • Flagg, Brackett & Durgin, Boston • D. D. Foster, Pittsburgh • Faville-Levally, Chicago Lester Oberholz, California • Gordon D. Hardin, Louisville, Kentucky



You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

These same insulating materials can also be obtained in large size units called Johns-Manville Insulating *Fireblok*. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft.	29	35	42	48	58	63-67
Transverse Strengths, psi.	60	80	130	125	120	200
Cold Crushing Strengths, psi.	70	115	170	190	150	400
Linear Shrinkage†, percent.	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent.	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2,000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F.	0.77	0.97	1.51	1.92	2.00	3.10
1000 F.	1.03	1.22	1.91	2.22	2.50	3.20
1500 F.	1.27	1.47	2.31	2.52	3.00	3.35
2000 F.	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up.	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed.	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

†24-hr. simulative service panel test for JM-3000, 24-hr. soaking period for other brick.

*Conductivity is expressed in Btu in. per sq ft per F per hour at the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

Johns-Manville *first in* **INSULATIONS**

• Internal
• Top Flange Mounted
Liquid Level Controller !

The new BS&B "Climax" Type 887 top flange mounted Liquid Level Control is the ideal, economical installation where a corrosive medium precludes the use of external piping. The type 887 is exactly the same as the amazing new 888 without lower cage housing. A hanger is provided to position the displacement element at the required level.

New Cone Point Pivot is practically friction-free. Torque tube and housing is *removable and reversible* without dismantling controller housing. You can employ *two* torque tube housings for two pilots and/or mercury switches!

Standard unit may be used for interface level control between two non-miscible liquids. Special floats available for specific gravity indication or control.

Available in three- and four-inch ASA flange sizes in iron, steel or special alloys. Larger size steel or special alloy flanges available for special applications. Write for new, fully illustrated catalog today!

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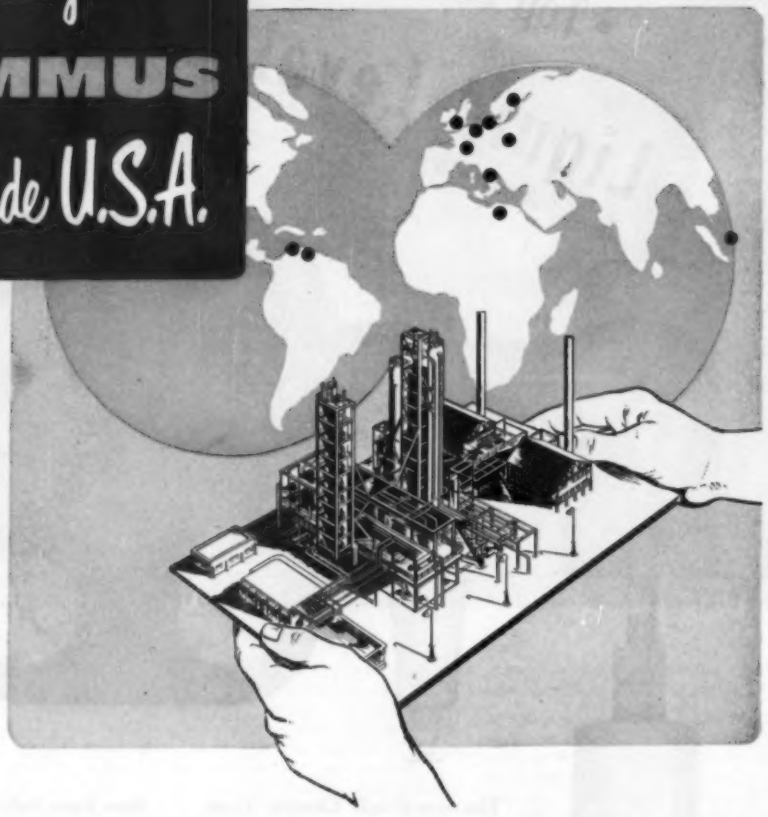
BS&B

"Climax" Type 887
INTERNAL TOP FLANGE MOUNTED LIQUID LEVEL CONTROLLER

...by LUMMUS ...outside U.S.A.



Dots on the globe indicate countries where scores of post-war refinery and chemical projects carry the seal "... by Lummus".

All classes of Lummus service—process design, engineering, construction—are represented in these overseas projects. In a number of cases, combined projects constitute complete oil refineries.

Processes employed include distillation; propane deasphalting; catalytic and thermal cracking; reforming; Polyforming; coking; lube oil manufacture by solvent refining, solvent dewaxing and clay treating; and petroleum chemicals production.

Each job—whether just starting, partially completed, or on stream—bears the Lummus stamp of over-all competence and international experience.

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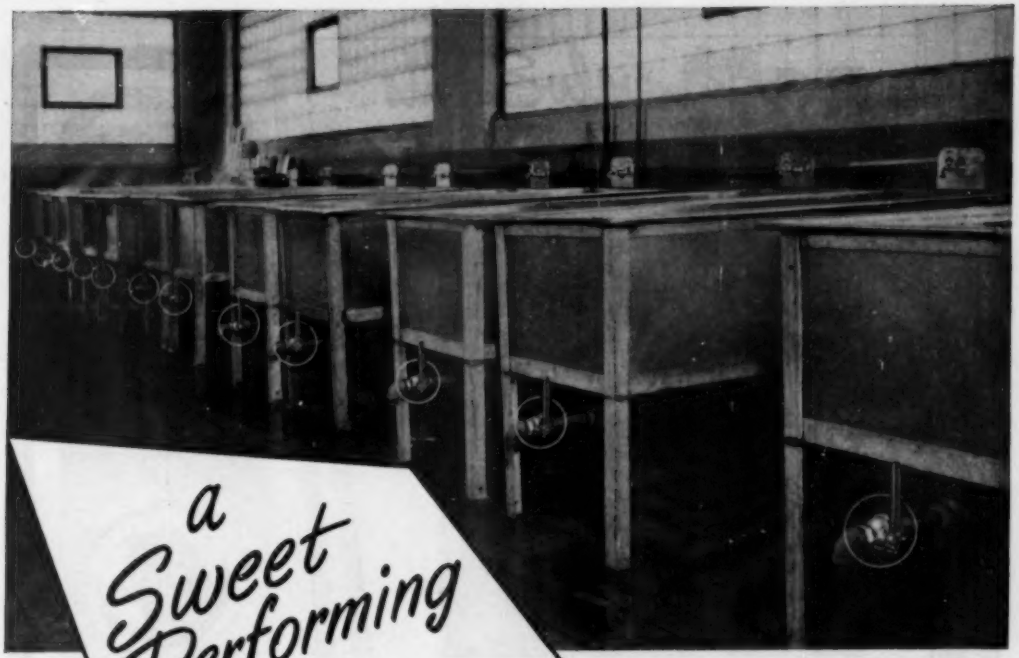
DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES



a Sweet Performing Valve

PROCESSING TANKS FOR CHERRIES AND SYRUP AT DAGGETT CHOCOLATE COMPANY, CAMBRIDGE, MASS.

These tanks at the Daggett Chocolate Company process thousands of gallons of syrup and cherries. The syrup and cherries are used to make Daggett candies and are also supplied to ice cream manufacturers and bakeries. Rockwood Ball Valves help keep these tanks in operation by giving longer and better trouble-free service. These Valves are constantly in use and have been on the lines for over 2 years — and during that time required *no maintenance*.

Floors are kept clean because when Rockwood Ball Valves are closed, they close tight and prevent syrup from dripping. Other makes of valves leaked as sugar would get into the valve slot and prevent a tight seal.

Rockwood Ball Valves are also used to draw-off corn syrup and on draw-off lines on cooking kettles.

Remember — every Rockwood Valve is designed and built to outlast any other valve on the market. See your distributor — see for yourself that Rockwood Ball Valves have the best engineering features your money can buy. Look for these outstanding features when you buy your valves — leak proof service, full *round* flow, easy operation, no maintenance.

Rockwood Ball Valves are recommended for 300 p.s.i. working pressure. Thousands of Rockwood Ball Valves are in service in oil refineries, food, paper, textile, chemical and rubber plants, etc. Write today for prices and sizes.

Distributors in all principal cities.

ROCKWOOD

2" Rockwood Ball Valve on corn syrup draw-off line. Tight seal of floating ball against synthetic seat prevents syrup from dripping on floor.

ROCKWOOD
SPRINKLER COMPANY
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WORCESTER 5, MASS.

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

RUGGED
Simplicity

Correctly engineered mechanically and metallurgically, all body assemblies of R-S Valves equal or exceed A. S. A. standards in every detail. These valves are designed and constructed for rugged service and provided with such safety factors that they will exceed service expectations as well as reduce pumping and blower costs.

Consider also the few working parts, greater control rangeability, the self-cleaning feature and the fact that R-S Valves are readily adapted to automatic operation. Know the rugged simplicity of R-S Valves, and get the most from your valve investment.

District offices are listed in telephone directories as, "R-S Products Corp'n Valves".

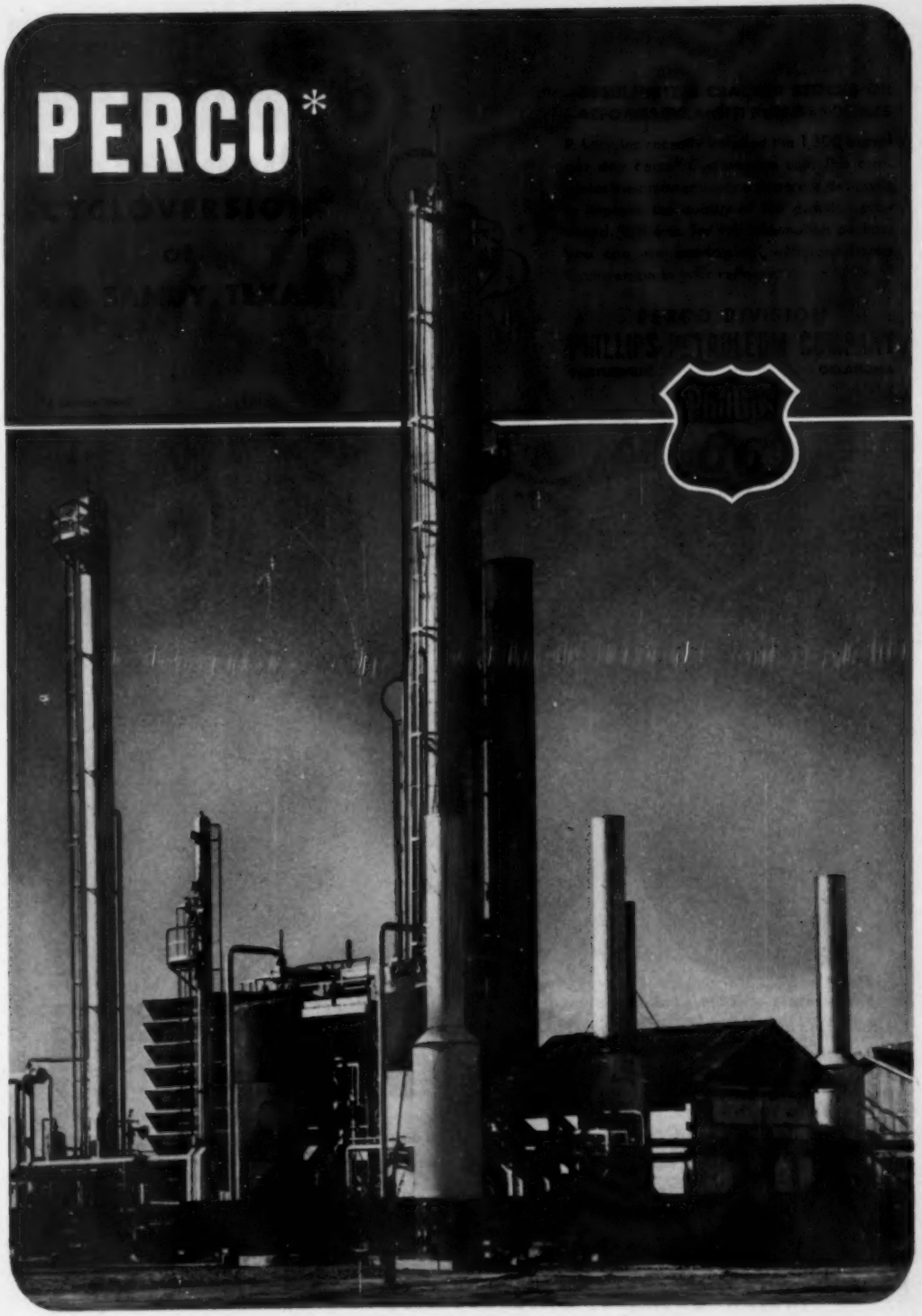
R-S PRODUCTS CORPORATION
4600 Germantown Avenue, Philadelphia 44, Pa.
An S. Morgan Smith Company Subsidiary

No. 782—Heavy Duty Rubber Seated Wafer Type Valve with 5° angle seated vane and enclosed gear reduction drive. Gland can be removed and stuffing box repacked without removing prime mover.

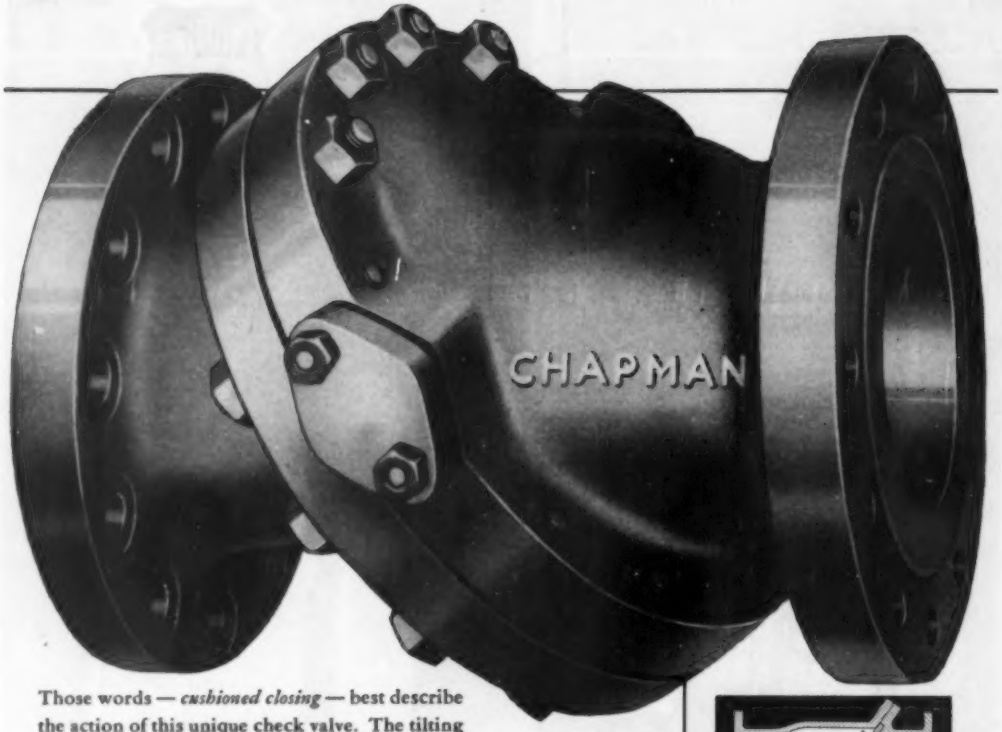
No. 739-740—Sixty-inch, 50-pound Heavy Duty Valve with gear reduction drive and handwheel for handling water at 40 psig. Vertical valve stem enclosed in steel pipe support. Thrust bearing absorbs vertical load.

No. 730—R-S Heavy Duty Floor Stand for rugged service in connection with any standard R-S handwheel operated valve.

No. 767—A 3-Way Valve (Two 24-inch 125-pound Cast Iron Valves bolted to 125-pound American Standard Tee). Electric motor operated by cross linkage. Automatic declutching handwheel for emergency operation.


PERCO*

Stop Expensive Slamming With the Cushioned Closing of CHAPMAN TILTING DISC Check Valves

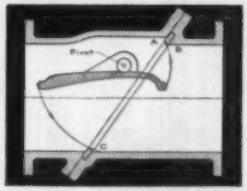


Those words — *cushioned closing* — best describe the action of this unique check valve. The tilting disc works with the stream—opens easily, closes quickly, *yet quietly.* There's no slamming — no resultant destructive stresses on the pipeline.

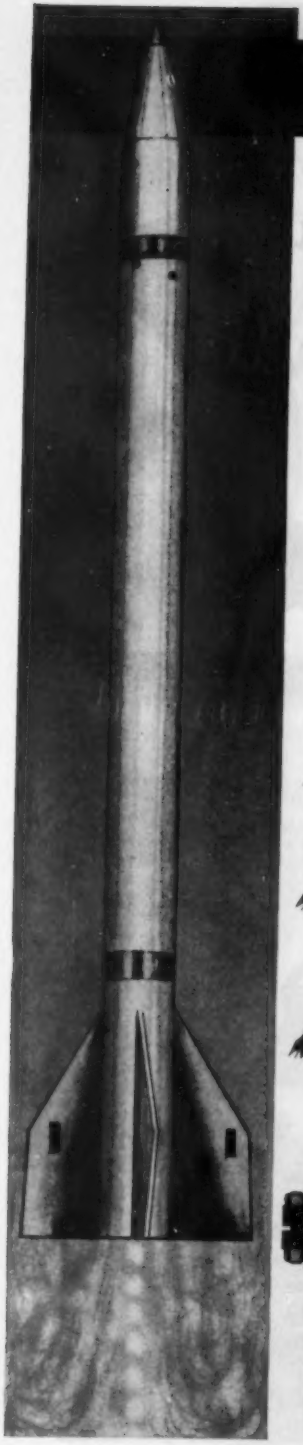
As a result of this smooth, *cushioned action*, maintenance costs are at a minimum and savings of from 65% to 80% in head losses can be obtained over conventional-type check valves.

Send today for the bulletin describing this unusual valve.

THE CHAPMAN VALVE MFG. CO.
INDIAN ORCHARD, MASSACHUSETTS



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.



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Improved LEVEL-TROL®

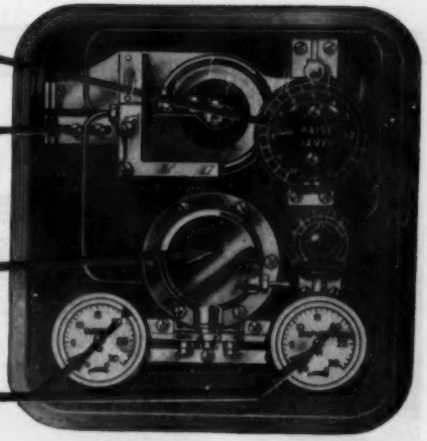
FOR LIQUID LEVEL CONTROL TRANSMISSION and INDICATION

Improved Feature
New level set adjustment. More highly visible.

Improved Feature
New factory calibrating adjustment makes possible accurate setting of proportional range over full float length.

Improved Feature
New relay—more compact—easily removed—easily assembled.

Improved Feature
Operating medium and diaphragm pressure gauges are glass-enclosed.



Type 2500-249 Level-Trol

• This improved Fisher Series 2500 Level-Trol is designed to better meet the requirements of field service—to give longer life—ease of maintenance. It still combines proportional range and specific gravity setting in one simple adjustment. Die cast weather-proof pilot case with black enamel finish, and improved lock hasp. Series 2500 Pilot Assembly is interchangeable with Fisher Series 2405 Pilot Assemblies now in service.

FISHER GOVERNOR CO.

MARSHALLTOWN, IOWA

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FILTER

Gives You Greater Fabric Uniformity

The greater uniformity of Mt. Vernon Extra means more efficient filtering – greater clarification of filtrates, more complete recovery of solids.

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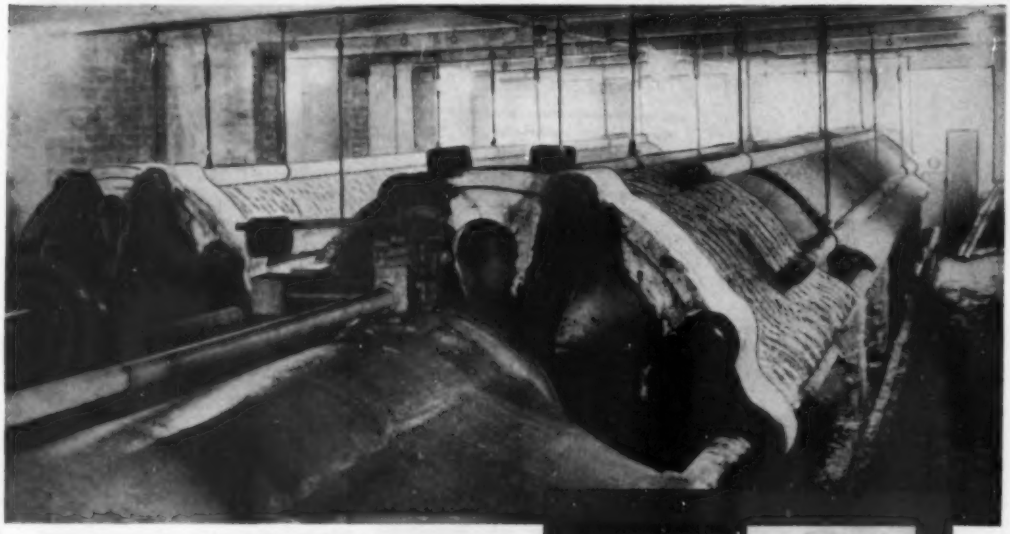
Mt. Vernon-Woodberry's staff of textile engineers is available on request to help you with your problems in development or application of industrial fabrics.



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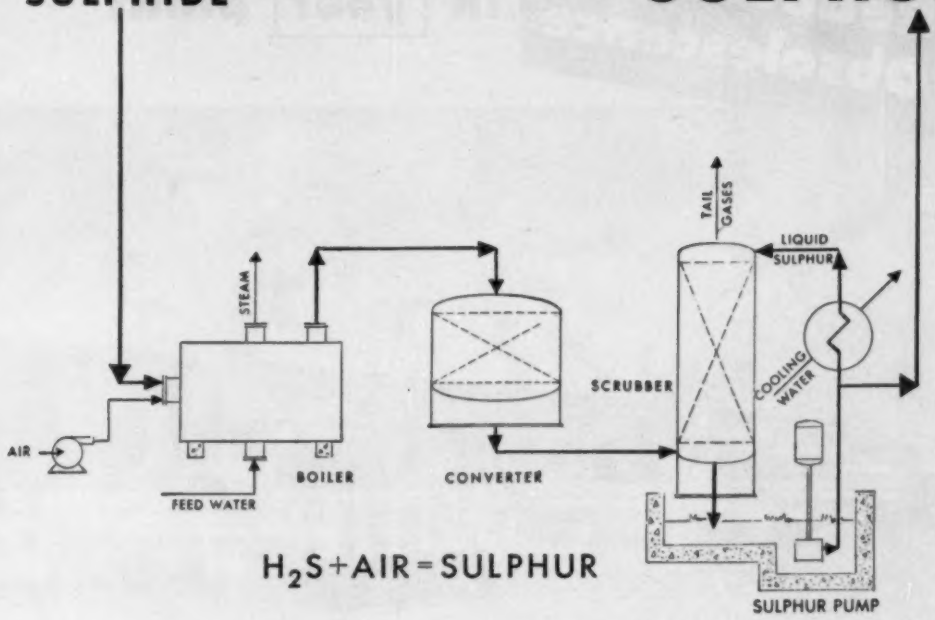
HYDROGEN SULPHIDE ..... TO ..... SULPHUR



...a one-man operation with GIRDLER plant

ONE MAN can operate the average Girdler continuous-flow Sulphur Plant. Instruments control the process, which is practically automatic.

The basic process material—hydrogen sulphide—can be removed easily from sour refinery gas, natural gas, or liquid hydrocarbons by a Girdler Girbotol Plant.

Up to 95% of the sulphur present as hydrogen sulphide can be recovered with a two-stage plant. A single-stage plant recovers up to 85% of the sulphur.

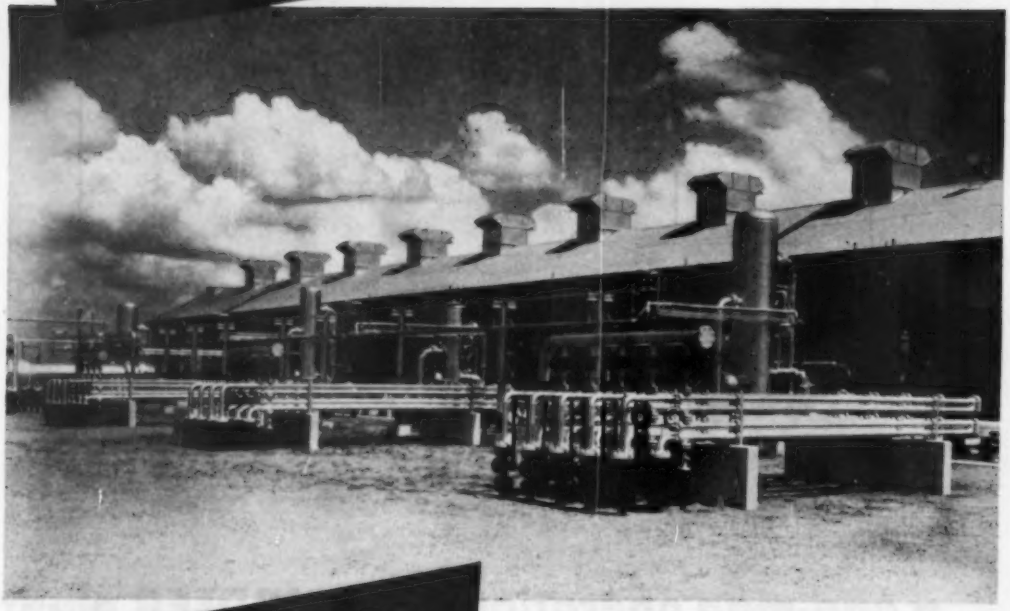
Write for complete information. The Girdler Corporation, Gas Processes Division, Louisville 1, Kentucky.

SULPHUR IS SCARCE! ARE YOU THROWING IT AWAY?

If you remove hydrogen sulphide from gaseous or liquid hydrocarbons, you should consider converting it into a valuable by-product. The acid gas stream from a Girbotol purification plant is usually an ideal feed material for sulphur production.

THE GIRDLER CORPORATION
Gas Processes Division

Reduce Obsolescence in your plant



with **BROWN FINTUBE** ***sectional hairpin heat exchangers***

● Brown Fintube's interchangeability of parts, exacting design and precision manufacture has "licked" obsolescence.

The sections can be used in one bank after another — on different duties — and different products. A bank can even be broken up and the sections shipped to two or more plants, miles apart, re-assembled and reused. Sections not in use serve as "stores" for other sections on stream. They are never obsoleted by changes in duty or plant re-arrangements. You can use and reuse them until they are completely worn out. Estimates and quotations furnished promptly. ***Write for Bulletin No. 481.***

THE BROWN FINTUBE CO.

Elyria, Ohio

Sectional Hairpin Heat Exchangers
Tank Suction and Line Heaters
Fintube Heaters for Bulk Storage Tanks
Indirect Process Air Heaters
Fintube Heaters for Processing Tanks
Integral Welded Fintubes for Any Heating, Cooling or Heat Transfer Service

NEW YORK • BOSTON • PHILADELPHIA • WILMINGTON • PITTSBURGH • BUFFALO • CLEVELAND • CINCINNATI • DETROIT • CHICAGO
ST. PAUL • ST. LOUIS • MEMPHIS • BIRMINGHAM • NEW ORLEANS • TULSA • HOUSTON • LOS ANGELES • SAN FRANCISCO

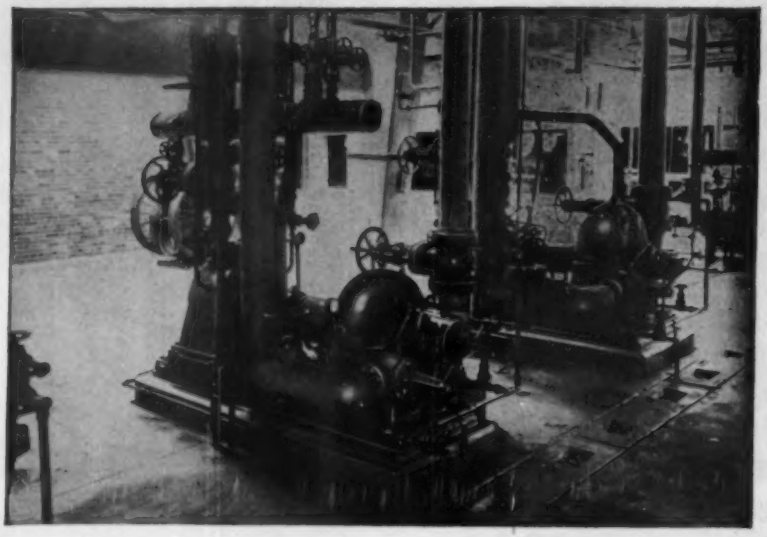
Thru the night . . . and the day

and year after year — high pressure gas will be delivered from this plant to cross-country gas pipe lines. The plant units to compress the inlet gas, remove hydrogen sulphide, extract and fractionate substantially all propane and heavier hydrocarbons, and remove water vapor from the remaining gas are integrated in process design, in lay-out, and in execution of detail to produce a smoothly functioning complete plant requiring minimum maintenance and operating expense.

This plant, designed and constructed for Gulf Oil Corporation to process gas from several fields in the Eunice area of Lea County, New Mexico, adds another major installation to the background of experience which has built the HUDSON reputation for complete dependability.

HUDSON
ENGINEERING CORPORATION
FAIRVIEW STATION • HOUSTON, TEXAS

TERRY



THE ROTORS OF THESE 75 H. P. TERRY TURBINES ARE DOUBLE RIM PROTECTED

The two 75 H.P. Terry Turbines shown above (in the plant of a leading refiner) employ the Terry Solid Wheel Rotor. The wheel is made from a single steel forging and the buckets are milled directly into the wheel. — All as shown in the illustration at the left.

The buckets are protected by rims at the sides of the wheel. These rims would take without damage any rubbing that might occur if the clearance became reduced.

With this construction it is impossible for the blades to foul and frequent inspections of the thrust bearing are not required to obtain safe and dependable operation.

This feature and many others of the Terry Wheel Turbine are fully discussed in our Bulletin S-116.

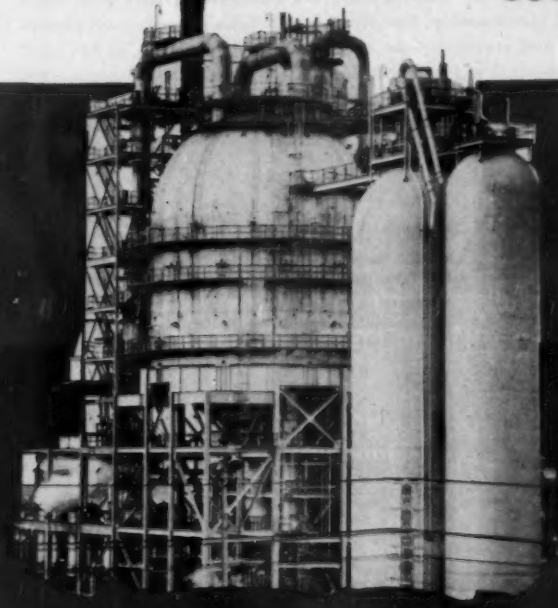
T-1169

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

A. P. Green
REFRACTORY
PRODUCTS

Castable Refractories
SK-7 and KS-4

Reduce Rebound Loss in Gun Application by As Much As 50%



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Built FOR better LIVING

That is what the carefully patterned mazes of refinery equipment, produced by Sun for many leading refineries, mean for America.

These towering refineries mean light, heat, comfort and power for the nation's homes and industries . . . fuel for transportation by ship, rail and motor car . . . mobility for our naval and military forces.

They must not fail . . . *they will not fail!* Into their making have gone Sun's engineering skill and craftsmanship, time-tested in wide fields of mechanical production . . . in refinery and chemical plant equipment, in shipbuilding, in fabricated steel work, in the renowned and powerful Sun-Doxford marine Diesel engines and other specialized machinery.

The more exacting the specification, the greater opportunity for Sun to maintain its engineering prestige.

Sun

SHIPBUILDING & DRY DOCK COMPANY

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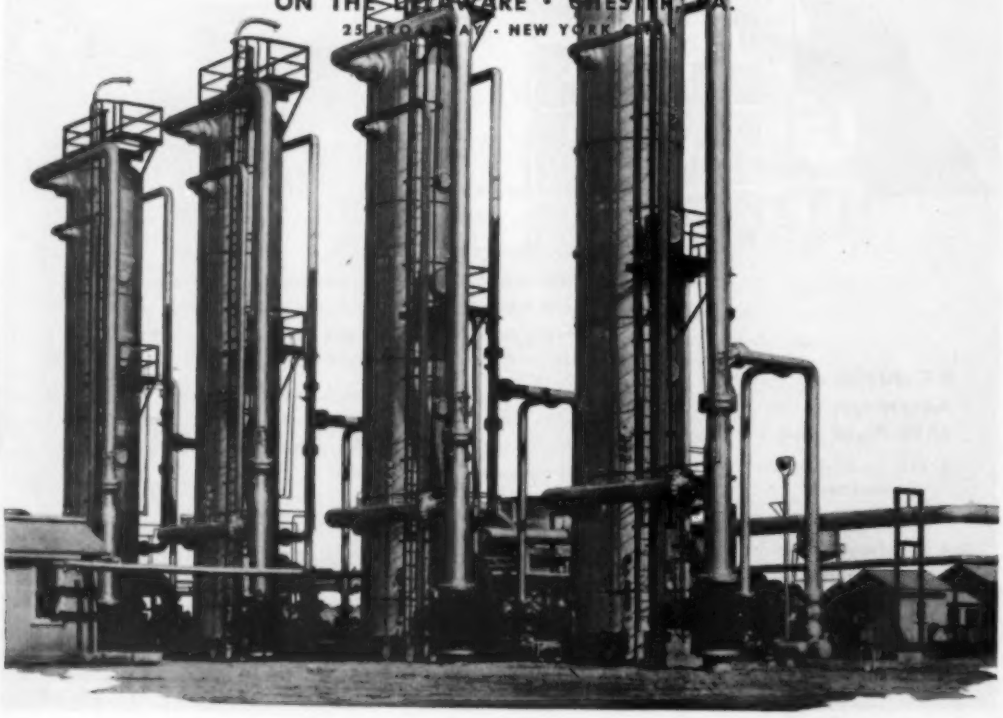
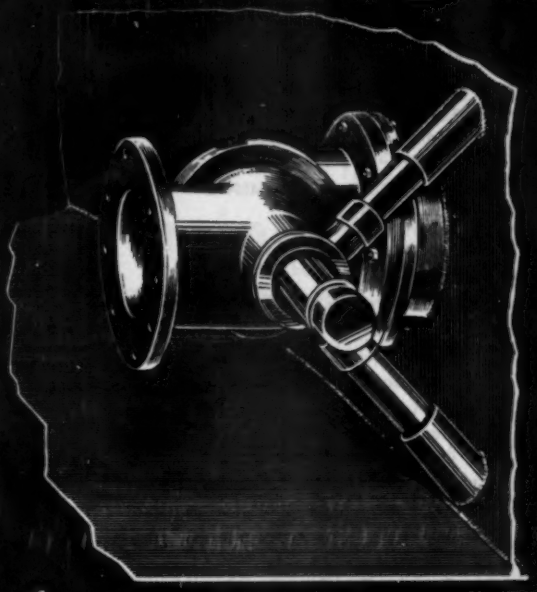


New Internal Security



S&J

A shift of a petroleum storage tank bottom with reference to the tank shell cannot damage or impair the operation of this new Shand & Jurs Swing Joint. Designated Fig. ST-235, this Swing Joint is mounted on the tank shell only. Should a tank bottom settle or shift, the S&J Swing Joint will be unaffected.

The stationary elbow of this S&J double elbow Swing Joint mounts on the internal nozzle flange, and pulls the swing elbow tightly against itself by means of a spring loaded rod. A boss on the swinging elbow rotates in a thrust bearing supported by two telescoping arms which are extended to the tank shell for welding. This design facilitates original installation, and contributes to long, trouble-free swing joint operation.

Shand and Jurs Co. 917 CARLTON STREET · BERKELEY · CALIFORNIA

NEW YORK 295 Madison Ave. CHICAGO 10409 S. Western Ave. HOUSTON 814 M & M Bldg. TULSA 310 Thompson Bldg. LOS ANGELES 714 W. Olympic Blvd. SEATTLE 3000 Western Ave.

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With the following AC-ME and R.S. Specialties accurate tests and measurements are guaranteed.

AC-ME Recording Gravitometer-Controller

CEMENT TESTING INSTRUMENTS
- Super Pressure Consistometer
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AC-ME Recording Gravitometer

Write today for your copy Bulletin No. 50 Describing R.S. and AC-ME Testing Instruments.

R.S. Dead Weight Gauge

Large stocks of laboratory apparatus and supplies for oil and gas testing are available for your convenience.

R.S.C. TULSA

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VARIETY

is not the spice of life here but it

Permits Piping Improvement

Midwest offers a large variety of welding fittings to help you improve your piping. Many of these fittings were originated by Midwest for the purpose.

For example, the Midwest Reducing Elbow saves a third of the welding, decreases turbulence and pressure drop and improves appearance when used instead of a standard elbow and reducer. Midwest Long Tangent Elbows have a tangent or straight section at each end equal to ¼ the nominal pipe size; this saves pipe, saves time in lining up, and often saves welding. (These are in addition to ASA Type and Short Radius Elbows.) Midwest Sleeves relieve the line butt weld of all bending stress and much of the tensile stress. Midwest Saddles restore the original pipe strength and reinforce the joint.

Use of Midwest Welding Fittings assures maximum improvement and economy in piping. For your welding fitting needs, get in touch with the Midwest Distributor near you.

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PIPING & SUPPLY COMPANY, Inc.

MAIN OFFICES: 1450 SO. SECOND STREET, ST. LOUIS 4, MO.
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MIDWEST WELDING FITTINGS Improve Piping Designs and Reduce Costs

piping upkeep *costs more* now!

Pressure-Seal Bonnet Gate—available in 600, 900, and 1500 pound classes

You spend less for it by using Dependable Quality

CRANE VALVES

. . . That's why more Crane Valves are used than any other make

NO BONNET JOINT LEAKAGE . . .
NO BONNET JOINT MAINTENANCE

Big maintenance savings can be made on high-pressure/high-temperature piping services by using Crane Pressure-Seal Bonnet valves in place of bolted bonnet valves. Once installed, these valves rarely need maintenance of the bonnet joint—line pressure keeps it leak-tight.

Lighter weight and more compact dimensions make savings in piping erection and suspension. Streamlined body design reduces insulating costs.

Other outstanding and typical features of Crane Pressure-Seal Bonnet Joint design are tailored-to-the-service alloy steels, Stellite trim, deep stuffing box, and flexible wedge disc in larger gates. In gates, globes, angles, or stop-checks, these valves are an investment in better piping performance at lower ultimate cost.

CRANE

CRANE CO., *General Offices:*
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Govan, Ferguson, Lindsay, Kaminker, Maw, Langley and Keenleyside, Architects

THE HOSPITAL FOR SICK CHILDREN

EQUIPPED FOR MODERN MIRACLES

Stone & Webster Engineering Corporation was retained as Project Manager during the planning stage of the Hospital for Sick Children in Toronto and later supervised and directed the construction. This hospital provides the most modern facilities for the care of sick children and for medical research and instruction.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

THEY GO TO BAT FOR YOU!

GENERAL PURPOSE

800* Hancock Gate

STEEL WELDVALVES

Star performance is what you get when you invest in Hancock Steel Gate Weldvalves. Here are several big reasons:

1. **Integral Stellite Seats** are trouble-free—hard, permanent, corrosion and wear resistant for extra long-life tightness.
2. **No Bonnet Joint** to cause leaks and gasket troubles. Lagging costs minimized—insulation can be run to the edge of the stuffing box.
3. **Dissimilar Materials In Seats and Wedge** assure long life—no galling! Wedge is "500 Brinell" stainless steel. Both wedge and Stellite seats are accurately finished and aligned for perfect tightness.
4. **Self-Storing Gland** is between the gland nuts — allows plenty of space along the stem to get at the packing, if necessary.
5. **Corrorion Resistant Back Seating** permits stuffing box shut-off around the stem when the valve is fully open. Repacking under pressure is safe!
6. **Yoke Post and Gland Nut Threads Protected** permanently regardless of corrosive atmospheres! Nut length is greater than its maximum travel—a number of yoke post stud threads are always covered, always workable.
7. **Ball Bearing Stem-To-Wedge Connection** distributes the load evenly, reduces frictional wear, makes operation easy.
8. **Packing is Easy.** There's plenty of space, and packing work is minimized because only the highest quality packing for the widest range of services goes into Hancock Valves.
9. **Interchangeable Parts.** Exact uniformity of all wedges, stems and thread bushings saves time, trouble, money.

Hancock General Purpose Steel Gate Weldvalves incorporate nearly 75 years of experience in valve engineering and manufacture. That's why they have design and operating features found in no other valve. Although Hancock Valves cost no more than ordinary valves, you can depend on them for month-after-month tightness in the most severe service.

See Your Nearby Hancock Valve Distributor. Tell him of your needs. You'll get prompt, efficient service.

When Hancocks go in, valve costs go down.

1877 HANCOCK U.S.A.

HANCOCK VALVES

MAXWELL MANNING MOORE TRADE MARK

A product of **MANNING, MAXWELL & MOORE, INC.** WATERTOWN 72, MASSACHUSETTS

MAKERS OF 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' INDUSTRIAL AND 'MICROSEN' ELECTRICAL INSTRUMENTS. BUILDERS OF "SHAW-BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

CALITE B-28

U. S. Patent 2,143,090

versus

35% NICKEL-15% CHROME ALLOY

We present comparative figures on all properties of these heat enduring alloys which are essential to the selection of the best furnace construction material.

HIGH TEMPERATURE STRENGTH

1% - 10,000 Hour Creep Value

CALITE B-28 (U. S. PATENT 2,143,090)	35% NICKEL – 15% CHROME
1800° F. 1950#/sq. in.	1675#/sq. in. (Univ. of Michigan)

DUCTILITY

Test at Room Temperature

		Tensile Strength	Yield	Elong. 2"	
(After 24 Hrs.—1400° F.)	Calite B-28	80,000#	35,000#	9.0%	*(Min. requirement) (Mfrs. Spec. 10-38)*
(As Cast)	35% Nickel - 15% Chrome	65,000#		4.0%	*(A.S.T.M. Spec. B-207-46T)*

OXIDATION RESISTANCE

Gain in Wgt. Mg./Sq.Cm. - After 1000 hours at 1800° F. - in air

Calite B-28	3.09
35 Ni. - 15 Cr.	3.33

CARBURIZATION

Depth of Carburization After 1000 Hrs. - 1800° F. in Quicklite "A"

Calite B-28	0.067"
35 Ni. - 15 Cr.	0.065"

TYPICAL PHYSICAL PROPERTIES

Tested at Room Temperature

		As Cast	After 24 Hrs. 1400° F.	After 1000 Hrs. Carburizing Atmosphere
Calite B-28 (U. S. Patent 2,143,090)	Tensile	85,050#	90,000#	74,900#
	Yield	57,250#	43,750#	40,400#
	Elong.	23.5%	15.0%	6.5%
35% Nickel 15% Chrome (Ht. 6298)	Tensile	68,300#	82,050#	70,800#
	Yield	38,500#	47,800#	29,830#
	Elong.	7.0%	3.5%	6.5%

Carbon	0.59
Chrome	16.05
Nickel	34.81
Silicon	1.16
Mang.	0.64

Calite B-28 (U. S. Patent 2,143,090) a chrome-nickel-molybdenum alloy

COSTS LESS — OFFERS MORE

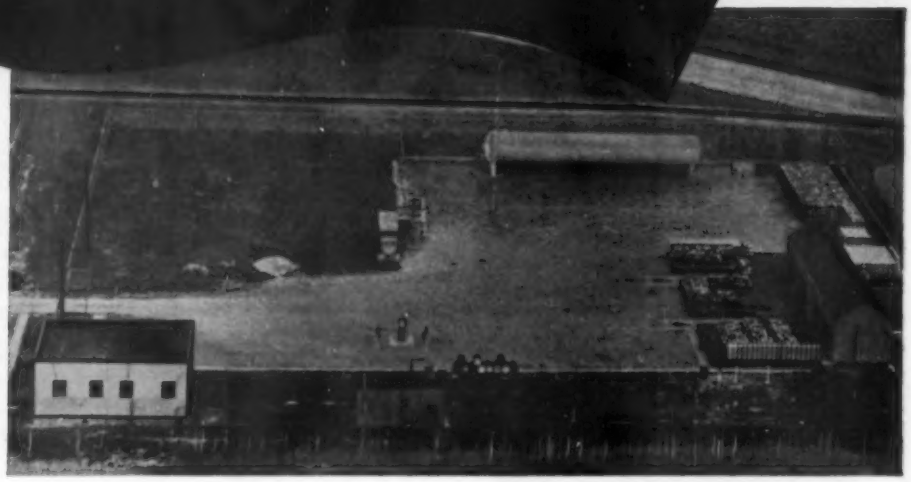
THE CALORIZING COMPANY

HEAT ENDURING AND CORROSION RESISTING METALS.
CALITE ALLOY CASTINGS—CALORIZED STEELS.

WILKINSBURG STATION PITTSBURGH 21, PA.

IS THE GAS YOU'RE DELIVERING HERE

PROOF AGAINST FREEZE-UPS?



Dry it with Lectrodryer . . . and be sure!

Customers burn up fast when their gas won't, due to regulator freeze-ups. You can prevent such complaints for your distributors by installing a Lectrodryer. Pulls moisture out of LP-gases, makes sure your gas is delivered DRY to the bulk plant.

Capacity? Standard Lectrodryers will handle any volume and pressure you may encounter. Leotrodryers DRY continuously, automatically, economically.

For LP-gas, for drying any other gases, air and organic liquids, Lectrodryers will give you extreme dryness—down to 3 or 4 parts per million or less. Our engineers will help you lay out the system and select the proper equipment. Just write Pittsburgh Lectrodryer Corporation, 307 32nd Street, Pittsburgh 30, Pennsylvania.

This Lectrodryer is DRYing propane

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In Australia: Birlec, Limited, 51 Parramatta Road, Glebe, Sydney.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

REGISTERED TRADEMARK U.S. PAT. OFF.

PRODUCE MORE WITH YARWAYS...

Is higher production your aim?

Then Yarway is your steam trap. Best steam trap performance requires condensate drainage *plus*—

1. **Air and gas removal.**
2. **Velocity scrubbing of condensate from heat transfer surfaces.**
3. **Keeping highest average temperature in the equipment.**

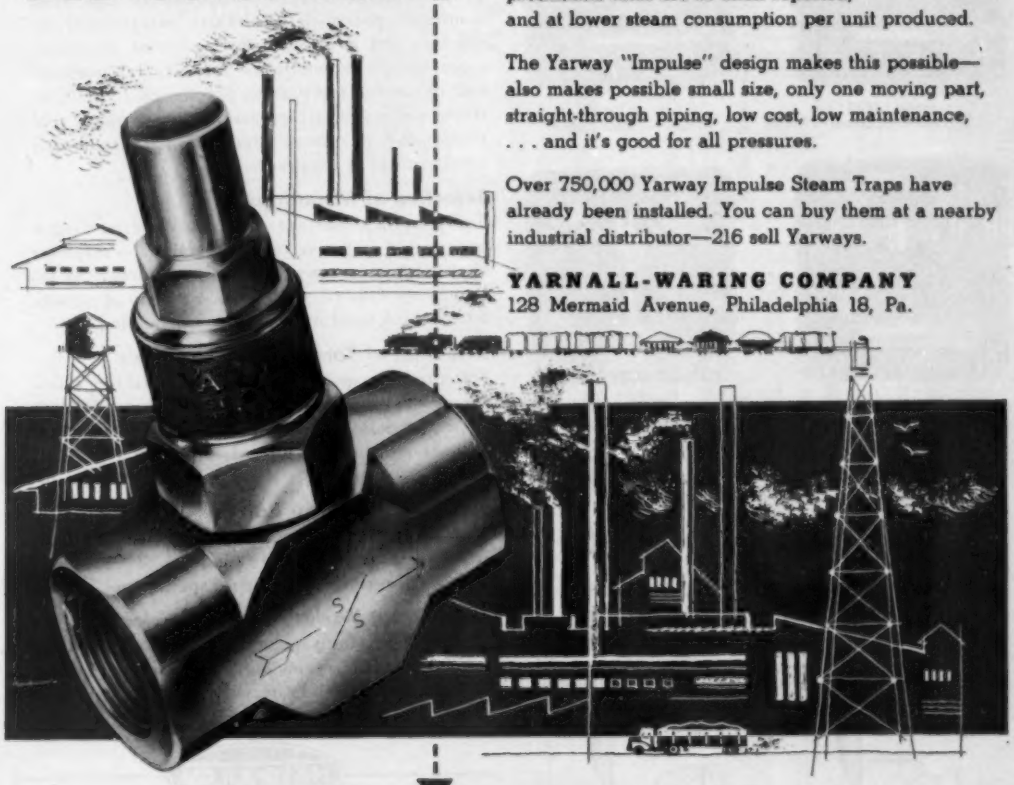
Yarway Impulse Steam Traps do all this, *sending the most premium B.T.U.'s at top temperature into your process or product.*

That's why equipment drained with Yarways gets "hotter, sooner" . . . why better quality and higher production rates are so often reported, and at lower steam consumption per unit produced.

The Yarway "Impulse" design makes this possible—also makes possible small size, only one moving part, straight-through piping, low cost, low maintenance, . . . and it's good for all pressures.

Over 750,000 Yarway Impulse Steam Traps have already been installed. You can buy them at a nearby industrial distributor—216 sell Yarways.

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.



FREE OFFER
Don't take our word for it. Test Yarway's production advantages in your own plant, without cost or obligation. Drop us a card. A trial trap will be delivered promptly.

YARWAY the steam trap designed with production in mind

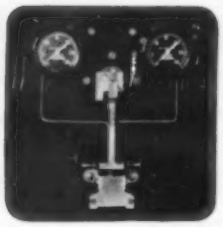
Only MASONEILAN 12,000 Series Liquid Level Controllers

Give You All These Advantages

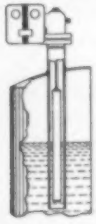
Model 12600
Proportional Control

Model 12610
Proportion-Reset Control

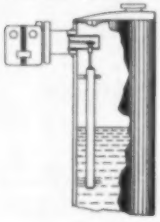
Model 12620
Pneumatic Transmitter



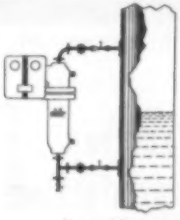
Model 12600-15
Pneumatic Signal Switch



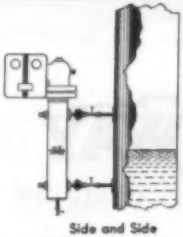
Top Vessel Mounting



Side Vessel Mounting



Top and Bottom
Screwed Connections



Side and Side
Screwed Connections

Nowhere except in the Masoneilan 12,000 Series Variable Displacement Level Controllers will you find such a choice of essential characteristics.

Wide Variety of Controller Types

Proportional controller, proportional plus reset controller, pneumatic transmitter, two-position differential gap controller, three-position pneumatic signal switch; duplex types—proportional controller and pneumatic transmitter, proportional-reset controller and pneumatic transmitter, proportional controller and pneumatic signal switch (and other combinations as required).

Selection of Mountings

Two internal mountings — top or side vessel flanged connection; eight external mountings — displacer chamber with screwed or flanged connections arranged for best adaptability to a variety of vessels. Right or left hand instrument case mounting.

Selection of Torque Tube Materials

Selection of torque tube assembly material best suited for the application. Standard is Inconel. Monel, Type 316 Stainless Steel, or Phosphor Bronze also available. (Materials offered subject to availability during shortages.)

Available in Many Ranges

12,000 Series Level Controllers are available in many standard ranges — 14 and 32 in.; 4, 5, 6, 7, 8, 10 and 15 ft. Ranges can be supplied for special applications.

Meet Great Variety of Applications

Typical applications include level in fractionating or crude towers, accumulators, separators, sumps, chillers, feed water heaters, settling tanks — many other applications.

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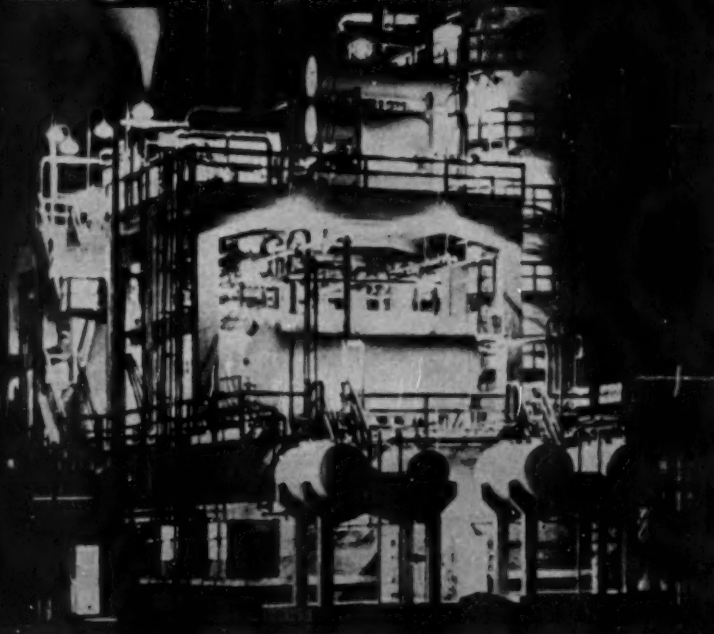

CHEMICAL PLANTS DIVISION

BLAW-KNOX CONSTRUCTION COMPANY

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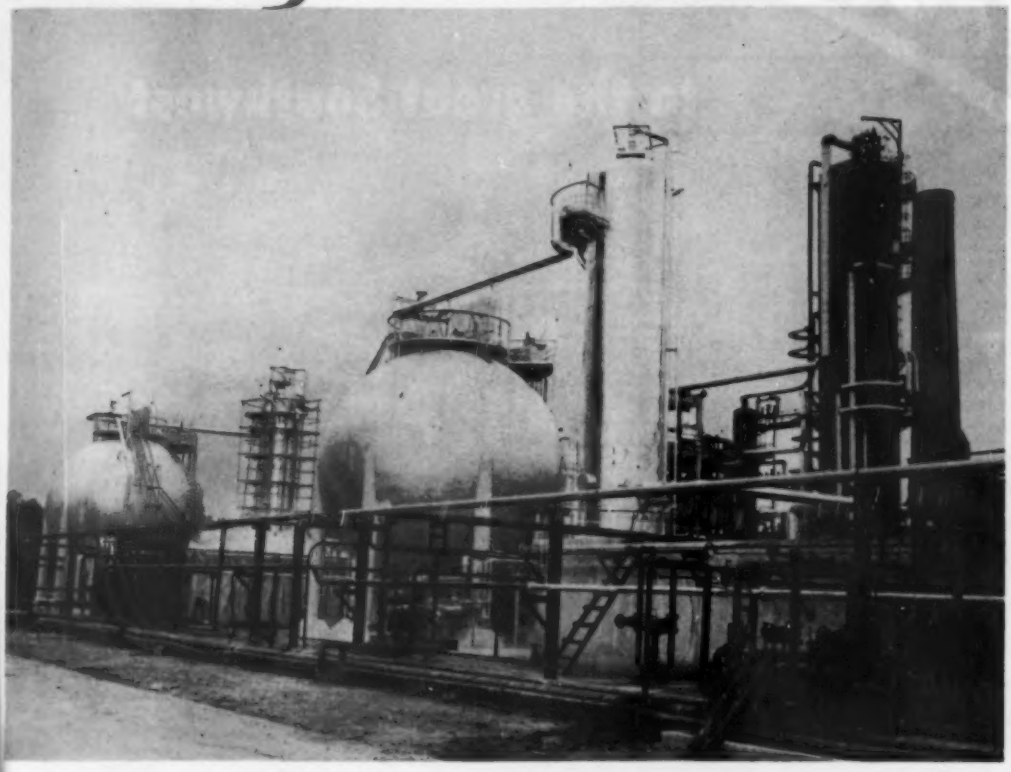
CITIES SERVICE } another leading refiner desalts with PETRECO



Cities Service has long been recognized for progressive leadership, dependable excellence of product and refining know-how. The first Petreco Desalter for Cities Service was installed in their East Chicago, Indiana, refinery. When their great new refinery at Lake Charles, Louisiana, was built, Petreco Desalters were installed as part of the regular refining flow system.

There is only one way to earn a *repeat* installation for a company such as Cities Service, and that is to produce results the first time. In this particular case the Petreco Electrosphere to the right in the picture above has delivered throughputs as high as 75,000 barrels per day for extended periods of time and was a considerable factor in the topping units continuous fifteen months run during which 30,000,000 barrels of oil were processed. Results such as these are the reasons why leading refiners continue to specify Petreco Desalting and Petreco Service.

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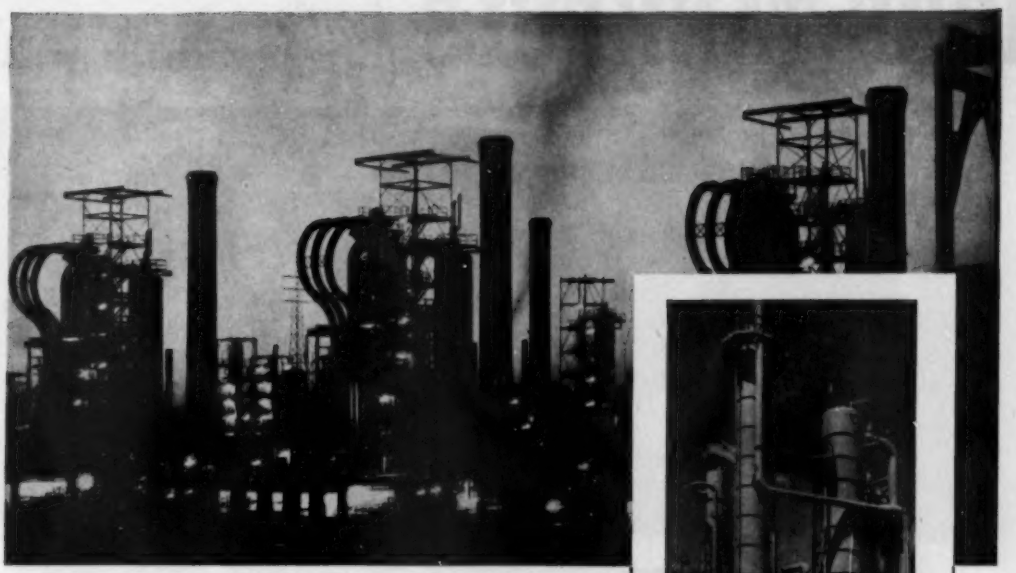


Fabricated by an equipment builder using the Lukenomics principle.

Equipment Report

...from a Petrochemical Operation

Temperamental efficiency giving your output plans an argument?

Mere replacement may not be the best solution. Perhaps you can do better. Consider, for example, design and fabrication know-how behind this clad steel distillation tower.

This is the responsible approach . . . the approach of a progressive equipment builder. The resourcefulness of such specialists is *your* best assurance of peak efficiency, economically achieved.

And builders like this apply Lukenomics, combining their own know-how with that of designer and engineer, as well as with our own knowledge of materials, their production and use.

Let us put you in touch with such resourceful builders. Write *today*, stating your problem. Manager, Marketing Service, Lukens Steel Company, 404 Lukens Building, Coatesville, Pennsylvania.

Here is a case where Lukenomics teamwork resulted in maximum productivity, economically achieved. Synthetic glycerine was to be purified by distillation in a column under high vacuum. The manufacturer supplied the *builder* with temperature, pressure and other process requirements. The column was then designed and fabricated to the specific needs. For assurance of high purity, at a sharp saving in equipment cost, Lukens Nickel-Clad Steel was used. Since completion, this tower has featured steady high output with rigid limits on maintenance and costs. And use of clad steel in this instance not only minimized initial cost, but saved important amounts of a scarce metal. *This is Lukenomics at work.*

Promote steel production generally—speed sale of your scrap.

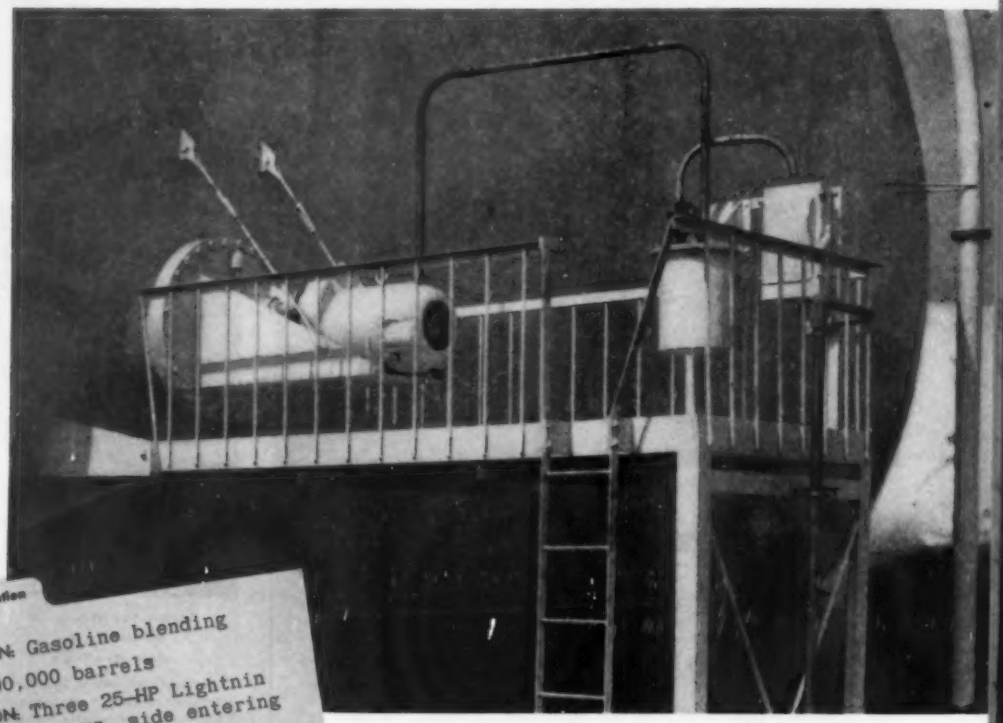
LUKENS

LUKENS STEEL COMPANY

OVER 140 YEARS' EXPERIENCE AS THE WORLD'S LEADING PRODUCER OF SPECIALTY STEEL PRODUCTS

STEEL PLATE | CLAD STEELS | HEADS | STEEL PLATE SHAPES

MORE TANKFULS *from the* same tanks



LIGHTNIN Installation #947

OPERATION: Gasoline blending

TANK: 100,000 barrels

AGITATION: Three 25-HP Lightnin Mixers, side entering propeller type.

TOTAL INSTALLED HORSEPOWER: 75

BLENDING TIME: Less than 2 hours

Here's proof!

Yes, Lightnin Mixers give you *more product* from your present plant . . . boost your operating profit by speeding up the important mixing-blending operations . . . give you as much as *30% more capacity* with the same tankage.

The record speaks for itself. Lightnin Mixers have been *top choice* with refiners for more than 20 years. Got a mixing or blending problem? Call in your MIXCO representative, or write us today!

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LIGHTNIN PORTABLE MIXERS

World's largest-selling line. Electric or air motor, direct or gear drive. Sizes ⅛ to 3 HP.

LIGHTNIN SIDE ENTERING MIXERS

For tanks up to 5 million gallons. Gear motor or V-belt drive; motorless types. Sizes 1 to 25 HP.

LIGHTNIN TOP ENTERING AGITATORS

Turbine, propeller and paddle types. For open or closed tanks. 16 speeds available in new heavy duty drive. Sizes ⅛ to 500 HP.

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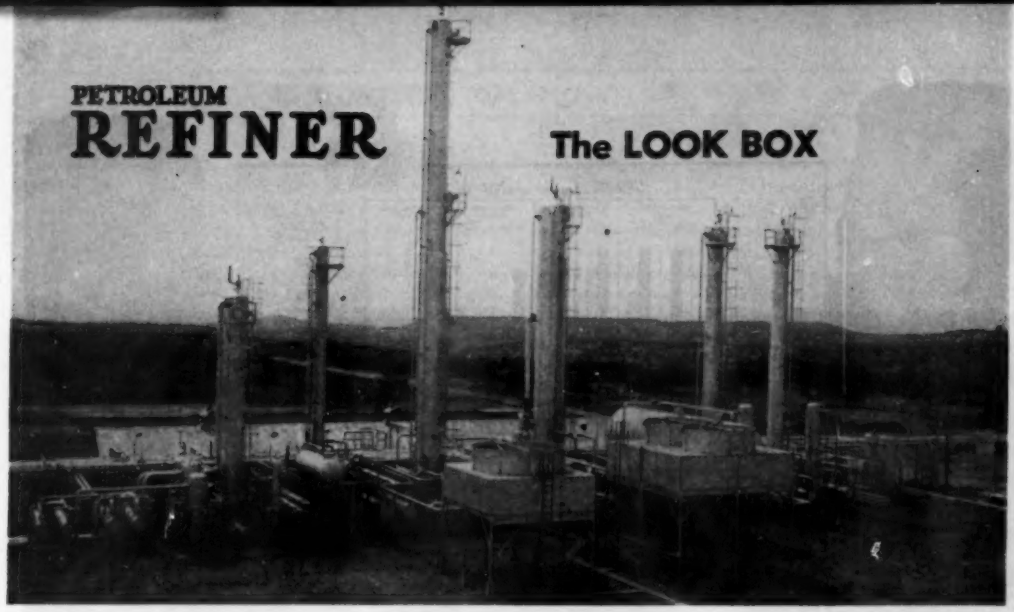


PERHAPS the most thought provoking of the technical matters discussed at the recent Tulsa NGAA meeting was the underground storage of LPG. In a paper, "Underground Storage for Liquefied Petroleum Gases," Frank Matheny of Sid Richardson Gasoline Company, reported on his company's experience in storing LPG in reservoirs made by dissolving salt by water circulation. Results are surprisingly good.

Underground LPG Storage

Design engineers, plant operators and sales departments have been plagued for years attempting to balance supplies and demands. Almost every year there has been considerable wastage of valuable LPG products during the summer months and a failure to supply peak cold weather demands of consumers. The extensive high cost of steel storage, it is agreed, has been responsible.

Underground storage methods offer marked improvement in these conditions. The new system is claimed to be potentially capable of preventing the flaring or wastage of products, while saving also untold tons of steel. The LPG manufacturer can, like the motor fuel manufacturer, as a matter of business routine, accumulate product in off-use season to fill consumer requirements in peak seasons. Manufacturers can sell LPG use more effectively since their feast-famine record can be put behind them. The present turbulent industry can be stabilized through adequate storage.

Briefly and simply, the storage method advocated and already commercially tested involves drilling into an underground salt reservoir. In a typical case, an ordinary jackknife rotary rig was used. Fresh water casing was set and cemented at 350 feet, the well drilled to a total depth of 1770 feet, 9⅝-inch casing cemented at 1162 feet, and 2½-inch tubing bottomed at 1748 feet. Cold water circulation was set up, feeding through the annular space and exciting through the 2½-inch tubing.

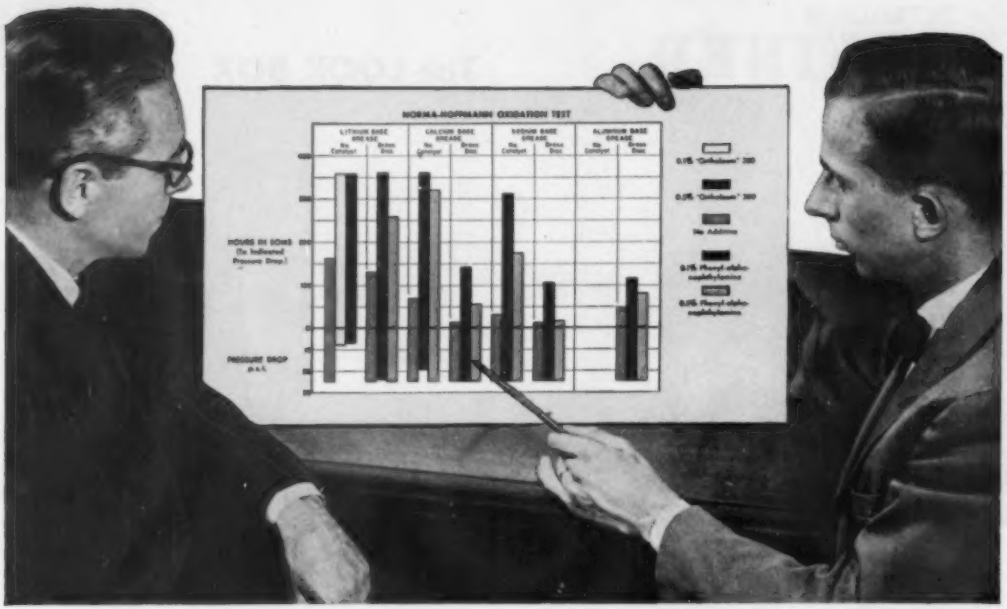
The reservoir completed and charged with LPG, as many as 15 tank cars per day have been loaded by pumping water down the 2½-inch tubing. Capacity of the reservoir can be accurately estimated by metering the fresh water. Losses of LPG have been low—about 50 barrels the first time the reservoir was used—and recoveries nearly complete. In tests witnessed by many outside engineers, it is said that 99 percent of products stored underground have been returned to surface steel storage.

BUSINESS as a whole, as well as separate segments, is being warned repeatedly against permitting encroachment by government upon the rights and freedoms of private enterprise. Resisting such encroachments sometimes is more difficult than sounding a warning, but industrial leaders, if they stay alert and put up the right sort of fight, can, at least, stay the evil day.

Meeting Needs for Oil

Louis Wilke of Denver, Phillips Petroleum Company marketing executive, before an API division of production meeting last month repeated the oft-stated belief that the petroleum industry can and will meet the increasing military and civilian oil needs as long as it is permitted

Top-of-Page Photo—Natural gasoline plant located in the Todd (deep) field, Crockett County, West Texas, and operated by Continental Oil Company. It has a daily capacity of 60,000 gallons.



YOUR CHOICE OF TWO DU PONT ADDITIVES FOR LOW-COST GREASE STABILIZATION

The demand for greater stability in greases is constantly increasing. This is due to the higher operating speeds and temperatures of modern equipment. To help you meet these conditions, and to increase the stability of your greases economically, Du Pont offers "Ortholeum" 300 and Phenyl-alpha-naphthylamine.

DU PONT "ORTHOLEUM" 300 supplies both antioxidant and metal deactivating properties. The result of this combination is outstanding where metal catalysis is a factor. On the other hand, "Ortholeum" 300 also shows marked superiority over Phenyl-alpha-naphthylamine in many non-catalyzed systems, as indicated in the Norma Hoffman comparison.

In many greases "Ortholeum" 300 provides high resistance to color deterioration, even under long exposure to light. It can either be added directly, or in an oil concentrate just prior to the final cooling period. For normal requirements, the treating cost of grease is under ½¢ per pound.

DU PONT PHENYL-ALPHA-NAPHTHYLAMINE gives excellent results in most non-catalyzed systems when the superior color stability of "Ortholeum" 300 is not essential. In equal concentrations, its lower price per pound means lower treating costs, too.

Since greases vary widely in their composition, their response to different stabilizers varies also, and the degree of stabilization required for different applications varies as well. Under the circumstances it will pay you to evaluate each of these two Du Pont additives in all of your greases —on the basis of quality as well as economy.

SAMPLES of "Ortholeum" 300 and Phenyl-alpha-naphthylamine are yours for the asking. Simply contact your Petroleum Chemicals Representative, or address your request to the Du Pont District Office nearest you.

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to operate through privately-owned companies in a free economy. Furthermore, he declared, there is no need for gasoline rationing in the foreseeable future and pointed out that companies operating in the Rocky Mountain region, for example, are contributing a steadily increasing amount of oil production from expanding exploration and development programs.

Wilke joined other petroleum leaders in urging the industry in the face of growing governmental control to inform the public of the industry's production efforts. He quoted a recent public survey conducted by Junior Achievement in which 65 percent of all teen-age youngsters said they favored government operation of all United States business. Such widespread attitudes are a challenge to private enterprise to develop factual information for distribution to high school students so that they might be better informed about the oil industry and its operations, Wilke declared.

Benefits for Mankind

THE PURPOSE of much of history's scientific research has been to add to mankind's storehouse of useful materials. Certainly this is true of the petroleum and petrochemical industries which during the past decade, particularly, have spent millions upon millions in promoting research, looking toward such benefits.

Early this month Du Pont was to have dedicated a new experimental station laboratory at Wilmington, Del., and one of the officials in making an advance announcement said "If this building were to be inscribed with a dedicatory legend, it could well read: 'To research in the new science of polymer chemistry with supreme confidence that by this means we shall be able to add to mankind's storehouse of useful materials'."

Inspection of the Polychemicals Department laboratory would demonstrate that research there, much of it dedicated to new fundamental knowledge, is aimed largely at the discovery of new and better plastics and superior manufacturing methods, materials, and other chemical tools of the plastics industry.

Physical testing of experimental plastics by methods now generally in use frequently results in destruction of expensive laboratory samples. Du Pont methods, demonstrated during a dedication tour early this month, make it possible to test materials without this loss. Time also is saved, since researchers do not have to wait until relatively large amounts of experimental plastics have been produced to obtain information about the mechanical and electrical properties of new plastics.

The new system for mass-producing chemical analyses employs inexpensive equipment that is so simple it does not require a graduate chemist for handling, and so compact as to constitute a portable laboratory which may be carried into the plant for studies necessary to keep the process under control. Because of the time saved more of these studies may be made and the process may be kept under closer control with greater uniformity of product quality as a result. The basic tools used are surprisingly simple; for chemical analyses the equipment includes: small pharmaceutical-type serum bottles, a rapid-weighing analytical balance, and a hypodermic needle. Each bottle stores the exact amount of reagent needed for a single determination. Pressure seals on the bottles insure against contamination or loss through evaporation.

Equipment for various other and necessary tests has been designed for the same simplicity and compactness.

Woman Scientist Recognized

WHILE women have been engaged in scientific research for many years it was only last month that a woman scientist was invited to address a meeting of the American Petroleum Institute.

Dr. Frances W. Lamb, Ethyl Corporation Research Laboratories, had studied the problem of engine deposit for three years prior to discussing it before the Refining Section gathering at Tulsa. Her subject was, "Formation of Engine Deposit Compounds by Solid-State Reactions," and pointed out that the importance of engine deposits and causes and methods of control of such deposits are changing with changing engine conditions; that even the findings of only a few years ago are now obsolete.

Employing X-ray diffraction and other chemical laboratory methods, Dr. Lamb and her co-worker, Leonard M. Niebylski, identified the actual compounds found in engine deposits and determined the principles by which their composition can be controlled.

She told her almost all-male audience of petroleum industry technical experts that, "We studied the physical and chemical properties of compounds identified as engine deposit components and found that all of these compounds can be formed by solid-state reaction and will react with each other at temperatures far below their melting points — temperatures such as exist on the cylinder walls in operating engines."

Formation of engine deposits is determined primarily by three factors according to Dr. Lamb. These are temperature of the engine parts on which deposits are laid down, the air-fuel ratio at which the engine operates, and the composition of the fuel.

How'd YOU like to be a Hunk of Coke...

with THIS coming at you?

There you were, settled in tight and snug inside the still tube, with nothing to worry about. Suddenly there's a high roaring sound, coming nearer — other pieces of coke come pouring past you like displaced persons in front of an advancing army. Then it's your turn—and zowie!—you're chewed up, smashed, torn loose and given the bum's rush out the tube.

That LAGONDA swing frame head has a punch like a boxing glove loaded with horseshoes. Behind it is all the authority of the LAGONDA 1100 Series motor, with its ball thrust bearings front and rear, and its unique all-over lubrication system. No coke can stand up against this pair.

Try this combination in your next clean-out. . . . Your nearest LAGONDA-ELLIOTT office will be glad to cooperate.

This is the 1100 Series LAGONDA Tube Cleaner Motor that has become familiar equipment in refinery circles. Operators dispute for the privilege of using it, where there's any choice. They know how good it is.

Full details in new Bulletin Y-29. Write today.

Y-296

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Lagonda

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Plants located at: JEANNETTE, PA. • RIDGWAY, PA.
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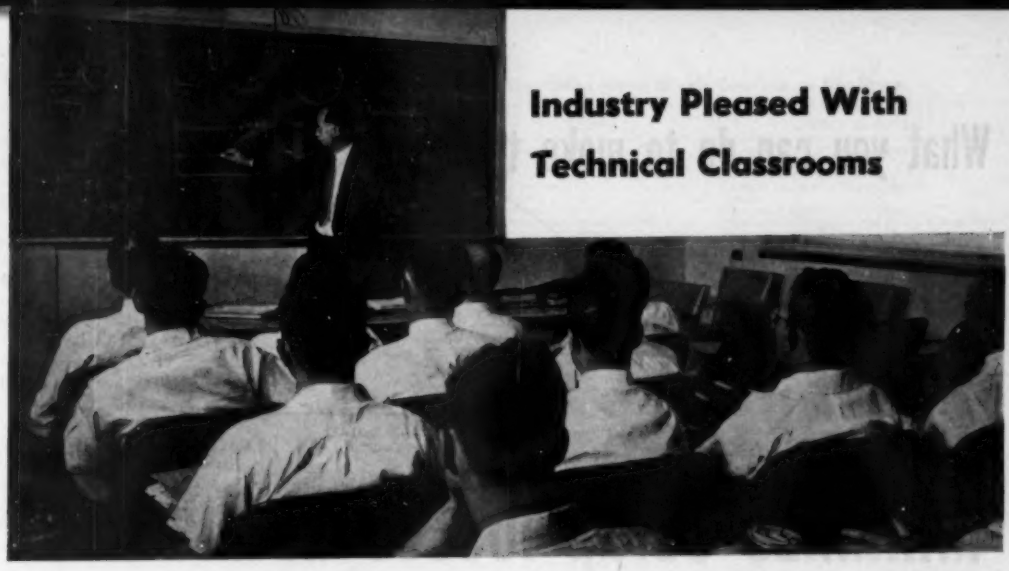
Industry Pleased With Technical Classrooms



H. DAYTON WILDE

Manager of Research and Development, Humble Oil & Refining Company, Houston

THE petroleum industry is proud of the progress which it makes, and does not hesitate to proclaim that "petroleum and progress go hand in hand." One aspect of this state of affairs is that, as science and engineering push forward the boundaries of knowledge, the industry is quick to incorporate this new knowledge into its technology. The large sums of money expended on research, and the large technical staffs provided by the companies, are striking evidence of the desire of the petroleum industry to keep abreast of the latest developments in science and engineering. In few, if in any other, industries does plant equipment become obsolete so rapidly, making it necessary to abandon good equipment merely because it has been superseded by something better.

Because science and engineering are currently making such rapid strides, it is easy for the technical personnel engaged in research and technology to get out of touch with new developments while they are on the job; thus they, themselves, as well as the plant equipment, become obsolescent. It is true that new and up-to-date information is brought into the technical organization when new graduates are employed, but in the average organization it is difficult to transmit this new knowledge to the older men. Furthermore, it is not long before the recent graduates themselves become the older men in the organization, and thus they lose touch with the new developments. By reading and studying the current technical literature, technical men can, in a measure, keep up with the new developments; but, as a practical matter, this is not too effective. The technical literature is so voluminous that the average technical man can cover only a small portion of it while on the job, and there are so many competing demands for his time off the job that there too he can cover only a small portion.

One way of overcoming this situation, which is practiced by a number of oil companies, is to send technical employes away to school. If an educational institution which gives the desired courses is located sufficiently near the plant or research laboratory, a few selected technical employes may take a course or two on a part-time basis. Another possibility is for a technical employe to obtain a leave of absence so that he may attend a school of his or the company's choice as a full-time student. In effect, these methods send the men to school.

HUMBLE HAS found that great benefits are derived by means of two forms of technical training for its refining research men and technologists. One is an advanced 10-week course for new technical employes which also serves as a refresher for some of the older ones. The other is a series of two-week courses taught by topflight professors of science and engineering, selected by the students themselves. Details of the twin plans was given by the author to a session on training technical men during the Tulsa mid-year meeting of the API Division of Refining.

Professor J. H. Rushton, Illinois Institute of Technology, explains a problem to his Humble class at Baytown, Texas.

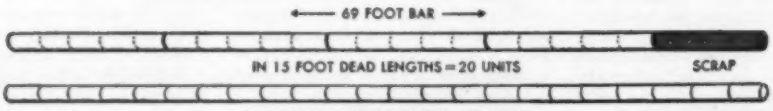
The alternative is to bring the school to the men so that they may get the benefits of advanced training with the least interference with their regular work and the least disruption of their home life. In connection with its technical and research personnel in refining, Humble has adopted the latter course. It provides two forms of classroom training. These are called, respectively, the Technical Service Practice School and the Humble Lectures in Science.

The practice school runs for a period of 13 weeks. The first three weeks are devoted to orientation, during which time the students are instructed in company history, company organization, the organization of the refining department, the functions of the various divisions and sections, and the relationships existing between them. The remaining 10 weeks are devoted to instruction in chemical engineering, with particular reference to petroleum refining.

A class is composed of some 15 to 20 students, the large majority of whom are newly employed chemical engineers; but the classes normally include 2 or 3 chemical engineers who have worked in the technical service division for a number of years, and who feel the need of a refresher course to sharpen their technical tools. During the three-week orientation portion of the course, the class is augmented by a number of new employes from other divisions who take advantage of the orientation portion of the course, but they drop out as soon as the chemical engineering portion of the course begins. Instead of using outside instructors, the practice school is taught

What you can do to make the supply of Stainless Steel go further

Minimize scrap losses at the mill by ordering the exact sizes that you will use



When you order sheets, plates or bars of Stainless Steel, don't confine your specifications to mere "dead lengths." Such procedure often leads to a waste of material.

Instead, place your orders in terms of *multiple lengths*. In other words, tell your supplier the actual dimension in which you will eventually use the steel. By doing this, you'll often get *extra* units from good steel that otherwise would be consigned to scrap.

For example, suppose you've been ordering 15-foot bars and are using the steel in 3-foot units. If the mill should roll a 69-foot bar, we could cut only four lengths or 20 3-foot units from it. But when ordered in multiple lengths, we could cut 23 units from the same bar, and scrap losses would be minimized.

The same thing holds true when you are ordering sheets, strip, or plates. The more we know how you will use the steel—the actual sizes you are planning to work to—the more chance we have of taking care of your requirements.

Cooperation from all concerned will stretch supplies of Stainless as far as possible. Specifying multiple lengths is one way you can help. (And it's equally important in your orders for alloy steels and plain carbon steels, too.)

Keep these points in mind, too, when you order Stainless.

Tell your supplier exactly where you'll use Stainless and how you'll fabricate it.

Indicate, if possible, acceptable alternates in composition, gage and finish.

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SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

1-983

UNITED STATES STEEL

by two chemical engineers from the technical service division. Obviously, the men selected as instructors must have a flair for teaching, and they must have kept up with those recent developments in chemical engineering which are applicable to oil refining by reading the current technical literature and attending appropriate courses given in the Humble Lectures in Science. A man serves as assistant instructor for one or two schools, and then serves as head instructor.

The chemical engineering portion of the course consists of a brief review of the principles of chemical engineering, followed by instruction in how these principles are applied to petroleum refining. Little attention is given to unit operations which are used only slightly in petroleum refining, such as filtration and drying; but the main emphasis is placed on combustion, flow of heat, flow of fluids, and distillation. The problems which are assigned are all drawn from petroleum refining. For example, if the problem is to calculate a heat exchanger, the data and conditions set up in the problem are those applicable to a specific situation in the plant. The students are shown how to use special calculation techniques, developed either at Baytown or elsewhere, for the solution of chemical engineering problems. These include short-cut methods which have proved to be effective and time-saving. In addition to the strictly classroom work, the students are organized into one or more groups for test work in the plant on operating equipment. For example, the group may run a test on a fractionating tower. After having secured the data, the group computes material and heat balances, separation efficiencies, and plate efficiencies.

Full-Time School

The practice school normally starts early in the fall after essentially all of the chemical engineering graduates who have been employed during the year have reported for work. For the duration of the course the students and instructors are relieved of all their other duties and responsibilities. The class is set apart, and it is understod that there is to be no interruption of the classroom work by calling on any of the students to take on assignments in connection with their regular work. Thus the students are able to devote their entire time to the work of the school, which consists of classroom lectures by the instructor, reading assignments, problem work, the study of plant units, and plant test work. Quizzes are given at intervals, and a final examination is held at the completion of the work. As in a regular school, every student is given a grade, and this is recorded in the individual's personnel file.

The cost of the school consists principally of salaries and payroll items applicable to the students and the instructors; and, as the course lasts 13 weeks, this amounts to a substantial sum. Nevertheless, in view of the benefits received, it is believed that the expenditure is well justified. In the case of the recent engineering graduates, it shows them how they can apply to the work which will be assigned to them the chemical engineering which they have learned in school. Inasmuch as several months, and even years, may have intervened since they have taken college courses, the classroom work brings back to mind many of the details which they have forgotten. However, the course is not merely a repetition or rehash of undergraduate courses, but rather is a continuation of chemical engineering on a graduate level. As a result of having been at the practice school, the young engineer is able to undertake regular work assignments with much less floundering, and he reaches a high degree of proficiency in a much shorter time. It is estimated that the young engineer can be brought "onstream" two or three years sooner than if he had not been at the practice school. There is another advantage in that some of the men realize, while they are students in the practice school, that they are not suited for technical work in refining. This may be because of temperament, aptitude, or preparation. Such men usually leave the company or are transferred to other work at the conclusion of the course, instead of wasting time trying to adapt themselves to technical service work. Those who do well in the course have more confidence in themselves and in their ability to handle the problems assigned to them when they return to regular work.

In the case of the older men, it affords them an opportunity to be brought up to date on the newer developments in chemical engineering which are applicable to oil refining. It is of particular value to those who have specialized in one narrow field of chemical engineering so long that they have become rusty and have lost the facility to work in other fields. Although the instructors have to put in a great deal of hard work in preparing for and teaching the course, they derive a great deal of benefit from it. As is usually the case, the instructor learns as much or more than the students who take the course.

Professors Who Have Given Courses at Baytown

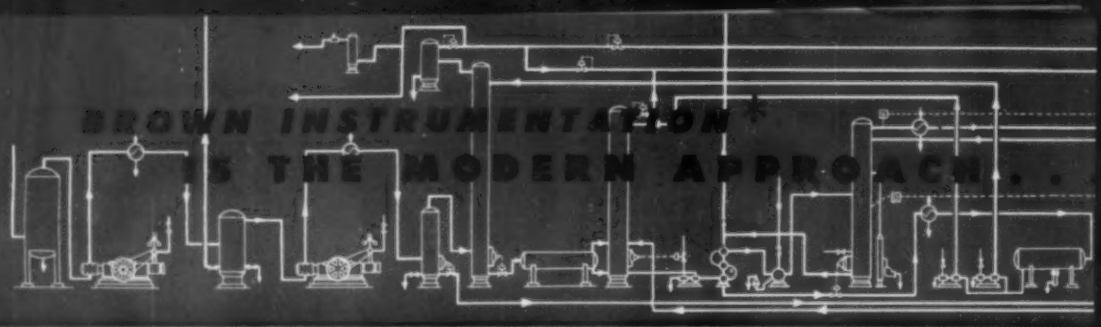
PROFESSOR	SCHOOL	SUBJECT OF COURSE
R. T. Arnold	University of Minnesota	Advanced Topics in Organic Chemistry
P. D. Bartlett	Harvard University	Theories of Organic Reactions
A. P. Colburn	University of Delaware	Advanced Topics in Distillation
B. F. Dodge	Yale University	Chemical Engineering Thermodynamics
Henry Eyring	University of Utah	Catalysis
R. C. Fuson*	University of Illinois	Advanced Hydrocarbon Chemistry
E. R. Gilliland*	Massachusetts Institute of Technology	Transference of Processes from Small- to Large-Scale
Joel H. Hildebrand	University of California	Thermodynamics of Nonelectrolytic Solutions
O. A. Hougen	University of Wisconsin	Applied Kinetics
H. A. Laitinen	University of Illinois	Physical Chemical Problems of Analytical Chemistry
H. L. Lochte	University of Texas	Organic Chemistry
F. A. Matsen*	University of Texas	Physical Chemistry
J. W. McBain	Stanford University	Emulsions
Linus Pauling	California Institute of Technology	Nature of the Chemical Bond
R. L. Pigford*	University of Delaware	Mathematics of Chemistry and Chemical Engineering
K. S. Pitzer	University of California	Spectroscopy and Statistical Thermodynamics
C. C. Price	University of Notre Dame	High-Polymer Chemistry
F. D. Rossini	Carnegie Institute of Technology	Chemical Thermodynamics
J. H. Rushton	Illinois Institute of Technology	Mixing
Hugh S. Taylor	Princeton University	Adsorption and Surface Phenomena
J. K. Tukey	Princeton University	Statistics
A. D. Walsh	Leeds University, England	Oxidation or Organic Compounds
S. Winstein	University of California	Mechanism of Organic Reactions

* Has given his course more than once.

Topflight Instructors

No claim for originality can be made for the practice school because a number of oil companies provide training for their technical men along this same general line; but the other type of technical classroom is original with Humble. Although the Humble Lectures in Science are approaching the end of their fifth year, so far as can be ascertained they have not been imitated. This program has brought to Baytown two dozen of the top chemists, physicsts, and chemical engineers of the nation to present intensive courses of study covering their specialties. A course usually lasts two weeks, and it is the equivalent of a semester of university graduate study. The professors and the subjects of the courses which they have given are listed below. As can be seen from a glance, these men are leaders in their respective fields, and the students taking their courses enjoy the enviable privilege of closely associating with the very men who are making the advances in these fields.

The students themselves play a large part in the selection of courses to be offered. The "academic year" runs from July to July, and currently five courses are given per academic year. In January or February of each year a questionnaire is sent to each technical employe in the technical service and laboratory divisions of the refining department. The questionnaire, which lists some 8 or 10 subjects which might be given in the forthcoming academic year, briefly outlines the subject matter which would be covered in each



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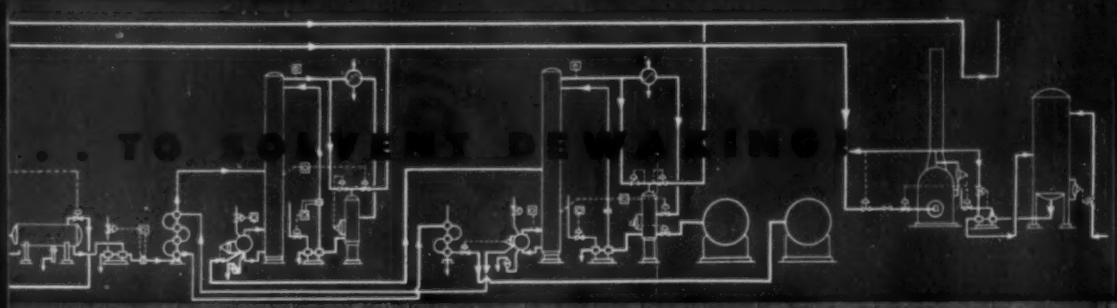

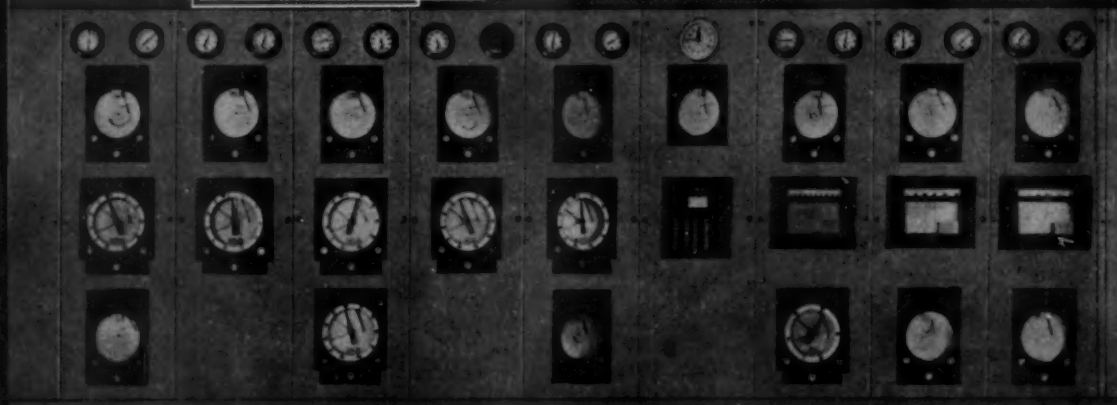

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course, and also gives the names of one or two men who might serve as a professor for each course. Each employe is asked to indicate in his order of preference the five subjects which appeal to him the most. The respondents are also urged to write in the name of other subjects which they believe would be of interest and, if they rate them among the first five, to so indicate.

These write-ins serve as the basis for subjects to be listed in the questionnaire the following year. Each respondent also indicates whether he would take a course in his preferred list in the event it is given and in the event he is selected to take it. The replies to the questionnaire are analyzed, and the subjects are then listed in the order of their popularity. The five most popular courses are tentatively selected for the program the following academic year. The courses thus selected are not necessarily limited to those listed in the questionnaire originally, but may include one or more write-in subjects if they prove to be sufficiently popular. After the list of courses has been prepared, a letter is addressed to each professor, inviting him to teach a specific course at Baytown. If a professor declines the invitation, another professor is invited to give the course; but, fortunately, to date no professor has declined an invitation unless he was faced with a serious conflict because of prior engagements, in which case he has offered to present the course during another year. Some of the courses have been so much in demand that the professors have repeated them another year. This has permitted employes who were unable to take the course the first time it was offered to enroll in the course when it was repeated.

The courses are scheduled to meet the convenience of the professors; but, because so many employes take summer vacations, an effort is made to avoid scheduling courses in July or August. Except for these two months, the courses are fairly evenly spaced throughout the year.

The classes are kept small in order to encourage an atmosphere of informality, and so that the students can have close personal association with the professor. The maximum number is rigidly held at 16, and the classes average 13 students. The students for each course are selected from among those who have indicated in the questionnaires that they would like to take the course. If more than 16 have indicated a preference for a particular course, the technical management selects the 16 out of the list which it feels will benefit most from taking the course. Inasmuch as the selections are made from those who have volunteered, no one who does not wish to take a course is forced to do so and, in general, the volunteer is able to take the course which he prefers. Some 85 to 90 percent of those receiving questionnaires indicate that they would like to take one or more courses. Although some students take courses more frequently than others, it has worked out in the past that almost every individual who wished to take a course has been able to take at least one course every three years.

The course content and the manner of presentation are left entirely to the judgment of the professor. The length of the course is also left up to the professor, but the great majority of the courses have covered a two-week period. Only a very few have run for three weeks. The students who take the courses are relieved of all regular duties, and are thus able to devote their full time to them. The courses are on a graduate level, and the consist of lectures, assigned reading, problems, and conferences with the instructor. Normally the professor gives a lecture which lasts from one to two hours in the morning and another of similar length in the afternoon, with the remainder of the regular working hours devoted to problems, conferences, and study. The students spend their evenings in reading, studying, and working out problems. On the completion of the course, a comprehensive final examination is given; and, at the discretion of the professor, there may be quizzes during the course. The students are given grades by the professor. The reasons for the examination and the grades are to promote a competitive spirit and to encourage the students to do their best. All in all, it is a very intensive period for the students, the majority of them devoting from 12 to 15 hours a day on this work.

Costs vs. Results

Besides the indirect cost for the salaries and payroll items of the students while they are taking the courses, the direct out-of-pocket cost includes the honorariums paid the professors, their traveling and living expenses, and the dinners which are given the professors, the students, and their wives at the conclusion of a course. The over-all cost varies and will range from $25,000 to $35,000 per year.

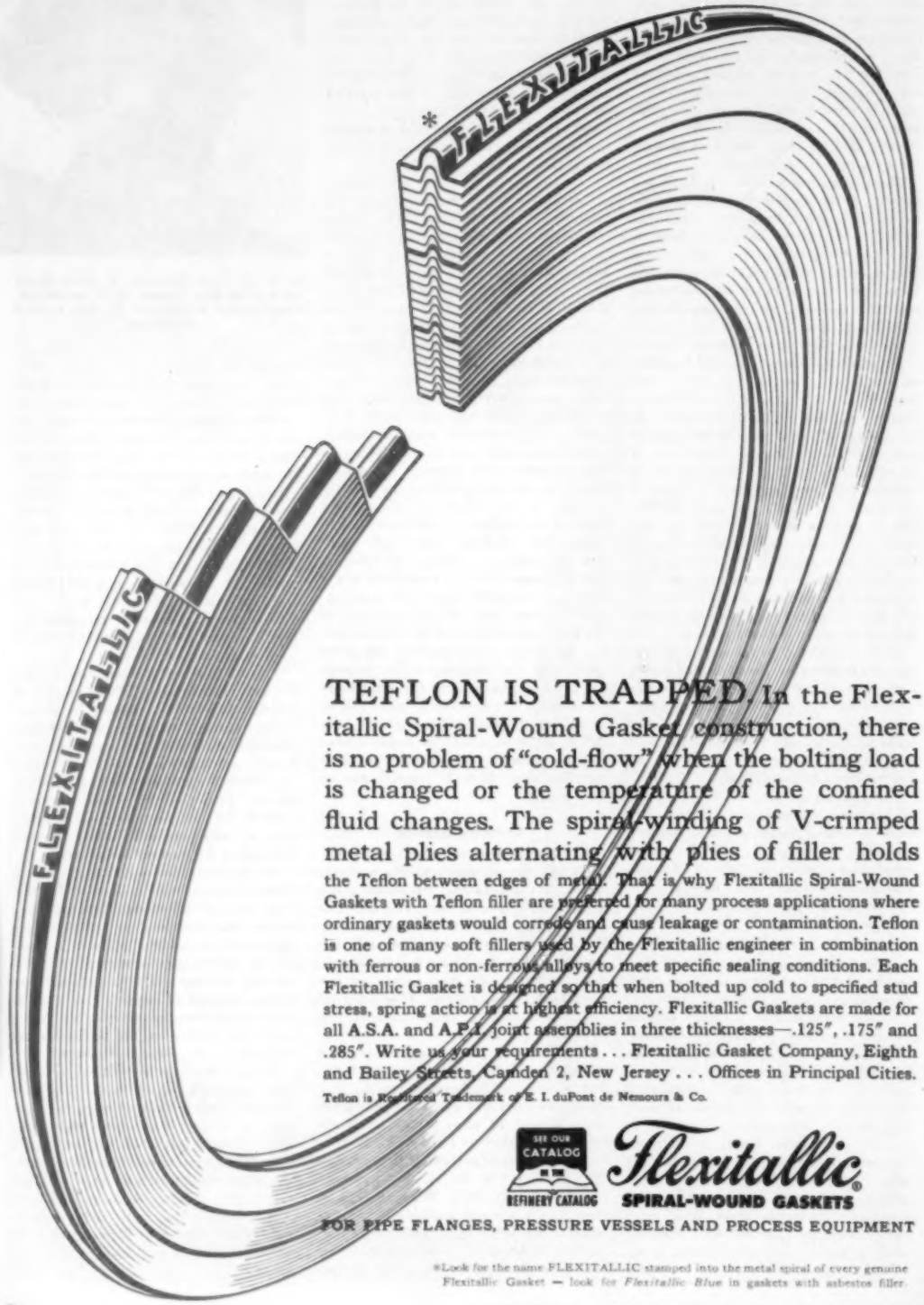
In return for these expenditures, the company and the employes reap a number of worthwhile benefits. In the first place, the employes who take the courses keep abreast of some of the latest advances in science and engineering. It is estimated that 80 percent of the information presented in the lectures has been developed since 1935. Much of it is so new that it was not available in colleges even a few years ago. This new information is brought to the employes by the very men who are making the advances. The employes are able to apply their new-found knowledge to their work—suggesting new approaches and working out new solutions to their research and plant problems. There is, of course the possibility that, by painstaking study and outside reading, a technical man may master some of the latest concepts and techniques; but, by taking a course, he is able to obtain the new information directly from the professors. Finally, there are the enthusiasm and intellectual stimulation which result from association with the professors. The students are quick to recognize the privilege and advantages of moving in such distinguished company.

Dr. C. C. Price, University of Notre Dame, makes a lab demonstration of the polymerization of methyl methacrylate. Dr. Price lectured at Baytown.

The students and the company are not the only beneficiaries. The Lectures in Science provide the means for better contact between education and industry. Through these close contacts, the professors are able to learn at first-hand the industry's problems and accomplishments. They are then able to carry back to the college classrooms a better idea of what students need to equip themselves for careers in industry.

The students themselves are most enthusiastic about the Lectures in Science. This is not surprising, because they realize that the program provides the equivalent of taking courses at a number of universities scattered over the country without their having to leave home. Instead of sending the men to these universities so that they can study under the professors, the professors are brought to the men at Baytown.

These two forms of training for technical employes, viz., both the Technical Service Practice School and the Lectures in Science, have been under way long enough that they are no longer considered experiments. Humble's refining management is convinced of their value; and, unless conditions in the future change so markedly that continuation of the courses is impractical, these technical classrooms on the job will continue.



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News Notes on Refinery and Other Plant Construction

Petroleum Refiner's Next "Box Score" Tabulation Will Appear in the July Issue

Pan-Am Southern's New Cat Cracker. (See item below)

Esso Expansion Will Add 6000 Barrels to Capacity

Expansion and modernization of the Everett, Mass., refinery owned by Esso Standard Oil Company will increase the capacity from 32,500 to 38,500 barrels per day. Scheduled for construction is an 18,500-barrel Fluid catalytic cracking unit, a 7000-barrel rerun pipe still, fractionator, gas-compression plant, and improved light-ends facilities. Installation is expected to be completed early in 1953.

The new facilities will make the plant self-sufficient in the production of quality gasoline whereas previously the refinery brought in components for the manufacture of high-grade gasoline. Gasoline and heating-oil output will be increased about 9500 barrels daily.

Because of existing facilities and equipment only 4000 tons of steel will be required for the project compared with 30,000 tons necessary to build an equivalent capacity. The plant will have a potential capacity of 84,000 gallons of high-octane aviation gasoline or, alternatively, raw materials for synthetic rubber.

Standard Oil Development Company will handle the process engineering. Construction contracts have not been announced as yet.

Shell Awards to UOP Expansion Job Contract

Contracts for the $12 million expansion program to be carried out at Shell Oil Company's LaPorte, Texas, refinery have been awarded to Universal Oil Products Company of Chicago which will handle design and construction, and to Procon, Inc., general contractors.

Catalytic units varying in height from a few feet to 100 feet will produce benzine and toluene, both used in production of high-octane aviation gasoline. As a necessary adjunct to the expansion program additional power house equipment will be installed. Construction work is expected to be under way late this summer.

Celanese to Build Chemical Plant at Pampa, Texas

A large chemical plant is to be built for Celanese Corporation of America in Pampa, Texas, about 50 miles east of Amarillo. Celanese President Harold Blancke says the plant will manufacture raw materials used in manufacturing synthetic rubber, explosives, pharmaceuticals, yarns and plastics and will supplement the producing activities of Celanese at Bishop, Texas.

Trade estimates indicate that construction will take one year after the unit is begun. The plant will draw on hydrocarbon feed stocks in the vicinity for chemical processing as well as on natural gas for fuel.

Tex-Harvey Will Build Absorption-type Gas Plant

Tex-Harvey Gasoline Company will begin construction of a modern absorption-type gasoline plant in Tex-Harvey oil field of east-central Midland County, Texas, some time in July. It is estimated that the cost of the plant together with a gathering system to bring gas to the plant will be between $5.5 to $6 million.

Initially the plant will process between 30 and 35 million cubic feet of wet gas per day but "capacity can be increased to process 50 or 60 million cubic feet by the addition of a recently developed refrigeration process."

Daily production operating under initial capacity is expected to run about 90,000 gallons of natural gasoline, 75,000 gallons of butane, and 90,000 gallons of propane. Operating pressure will be 825 psi.

Planning is underway, both for engineering detail and arrangements for obtaining materiel. Contracts will be awarded in June.

Pan American to Expand Its Texas City Refinery

Pan American Refining Company has announced plans to expand its Texas City, Texas, refinery although as yet the firm has not been granted a certificate by PAD. It is intended that the expansion shall include a fluid catalytic cracker and a polymerization plant to boost the production of aviation gasoline. Engineering plans are not yet completed.

German Refinery on Stream

A crude oil refinery located at Muelheim, Ruhr within the northwest German industrial area, recently went on stream after four months of construction. The plant contains a top-distillation and a catalytic desulfurization unit in addition to the refinery. Present capacity is approximately 4000 barrels per day of crude oil.

El Dorado Plant Equipped For Consumer Processing

Dedication of a second catalytic cracking unit at the El Dorado, Ark., refinery in April brought to a close the first phase of Pan-Am Southern Corporation's five-year multi-million dollar expansion program in the South. The new cat has a capacity of 9300 barrels per day of gas oil and can refine 84,000 gallons per day of high-octane gasoline.

Dr. J. W. Bertetti, former refinery manager, said that crude capacity had been increased to 30,000 barrels per day. In addition to the catalytic crackers, a new coker was completed in 1950, and the alkylation plant was completely renovated.

The unit was designed and constructed by Foster Wheeler Corporation.

Coalbrook Budget Boosted $14 Million by Government

An increased allocation by the South African government of 18 million pounds as against the previously announced 13 million will mean that SASOL can now build for a capacity of 60 million gallons of coal synthesis products at its Coalbrook refinery. The M. W. Kellogg Company is acting as over-all project managers and will have complete technical direction as well as responsibility for design and engineering of process facilities. Its subsidiary, Kellogg International Corporation, will handle procurement and supervision of construction.

Lubrizol Chemical Plant In Operation This Month

Lubrizol Corporation's new $2 million chemical plant in Deer Park, Texas, is expected to be in operation by the end of May. The Cleveland, Ohio, firm bought 32 acres of land adjoining Shell Oil Company holdings. The plant will be used for the manufacture of chemical additives for lubricating oil. Actual construction work is completed and all supervisory personnel have received training at the Cleveland plant.

French Plants Get Three New Personnel Buildings

Contracts by Socony-Vacuum Francaise for the construction of three new buildings have been awarded the John

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W. Harris Associates, Inc. Two buildings will be located at Gravenchon, near Rouen, while the third will be built at Frontignan, in South France near Sete. Work was initiated through the Harris corporation known as Societe Internationale d'Entreprise.

Gravenchon is to get a combination cafeteria and recreation building as well as a personnel building. The building at Frontignan will be a combination cafeteria and recreation building which will include guest facilities. Construction is scheduled for completion in the fall.

San Antonio Refinery Is Planned for Military Use

Military installations adjoining San Antonio will be supplied soon by a new 10,000 barrel-a-day refinery planned by Monarch Refining Company on a 130-acre site east of San Antonio.

A fast tax-write-off has been arranged for the $12.5 million unit and application has been made for an RFC loan. Refinery facilities will include a 4000-barrel Fluid catalytic cracking unit, 2500-barrel Platforming unit and a 2500-barrel Hydrofluoric acid alkylation unit. Universal Oil Products Company has submitted preliminary engineering designs for the units. A breakdown of products planned: 2675 barrels per day avgas; 4500 barrels 86 octane motor fuel; 1370 barrels diesel fuel; 900 barrels jet fuel and 700 barrels heavy fuel. It is anticipated that crude will be obtained from nearby pipe lines.

Pan American P & T Plans Expansion at Texas City

A 10 percent increase in capacity of its 115,000 barrels-a-day Texas City, Texas, refinery is planned by Pan American Petroleum & Transport Company in order to boost avgas production. Tentative plans include addition of a Fluid catalytic cracker and polymerization plant, engineering plans for which have not been completed. D. J. Smith, president, said certificate of necessity for construction has not been requested, although the company hopes to have the new facilities in operation by the end of 1952.

Geelong Refinery Reputed Australia's Largest Unit

Shell Oil Company of Australia has completed plans to build a $9 million refinery at Geelong, Victoria. The refinery, reputed to be the largest in Australia upon completion, is expected to produce 136 million gallons of gasoline, 23 million gallons of diesel fuel, and 38 million gallons of fuel oil yearly even during initial stages of production. E. N. Avery, manager of Australian Shell, said the company will get its crude oil from British Borneo.

McKee Awarded Mexican Lube-Wax Plant Contract

Arthur G. McKee Company has been awarded a $15 million contract by Petroleos Mexicanos to build complete lubricating oil and wax manufacturing facilities at its Salamanca Refinery. Products will be made entirely from Mexican crude oil. McKee officials say construction will start immediately, work to proceed as rapidly as materials are available. McKee just finished building the refinery at Salamanca a few months ago.

Over $300 Million Granted Tax Amortization to Date

Upon recommendation of PAD the Defense Production Administration has approved 21 additional oil expansion projects costing more than $212 million, as well as 45 projects for industries allied to oil, for fast tax amortization. This brought the total oil projects certified for fast write-offs to 49, and at a total cost of well over $300 million.

Ethyl Corporation was granted an 85 percent write-off on its $44,135,000 anti-knock compound plant at Houston. Following is a list of the other 20 projects certified, showing company, type of product, total plant cost and percentage of cost approved for fast write-off:

Sun, Marcus Hook, Penn., benzene and toluene, $8,380,000, 85 percent. Sun, Delhi, La., isobutanes, $238,497, 85 percent. Sun, Marcus Hook, Penn., avgas, $2,577,145, 100 percent.

Indiana Standard, Whiting, Ind., avgas components, $938,500, 100 percent. Indiana Standard, Whiting, avgas, $2,327,500, 100 percent. Indiana Standard, Neodosha, Kans., gasoline, $10,029,000, 80 percent. Indiana Standard, Sugar Creek, Mo., gasoline and kerosine, $21,170,000, 75 percent.

Ethyl Corporation, Baton Rouge, La., anti-knock compounds, $4,041,000, 75 percent. Ethyl-Dow Chemical, Freeport, Texas, ethylene dibromide, $6,155,000, 100 percent.

Ashland Oil & Refining, St. Elmo, Ill., gasoline and kerosine, $665,000, 75 percent. Ashland Oil & Refining, Canton, Ohio, gasoline, jet fuel and butane, $3,870,000, 75 percent.

Premier Petroleum, Fort Worth, Texas, gasoline, $650,000, 75 percent. Premier Petroleum, Fort Worth, jet fuel, butane, and gasoline, $3,580,000, 75 percent.

Cities Service, Ponca City, Okla., gasoline and fuel oil, $6,500,000, 75 percent. Continental, Lake Charles, La., gasoline components, $23,820,150, 80 percent. California Refining, Perth Amboy, N. J., gasoline and fuel oil, $32,950,583, 80 percent.

Frontier Natural Gasoline, Loco Hills, N. Mex., natural gasoline, $703,986, 75 percent. Gulf Oil, Pittsburgh, ethylene, $15,427,000, 80 percent. Kanotex Refining, Arkansas City, Kans., high-octane gasoline, $2,347,423, 75 percent. Monarch Refining Company, San Antonio, Texas, avgas, $11,925,000, 80 percent.

Phillips, Borger, Texas, avgas alkylates, $15,573,700, 75 percent. Sinclair Refining, Houston, butylenes and isobutanes, $27,000,000, 75 percent. Taylor Refining, Corpus Christi, butanes, gasoline and fuel oils, $5,057,493, 75 percent.

Among the certifications granted companies allied to the oil industry were: Mathieson Hydrocarbon Chemical, Doe Run, Ky., isobutane, $18,980,095, 75 percent. Lufkin Foundry & Machinery, Lufkin, Texas, oil pumping units, $100,000, 75 percent. Brown & Root, Houston, rebuilding tanks, $329,923, 75 percent.

Gulf Plans 76,000 Barrel Expansion at Philadelphia

An increased capacity of 76,000 barrels-a-day is planned for Gulf Oil Corporation's Philadelphia refinery. A vacuum and topping unit, another catalytic cracking unit, a reforming unit and various supplementary equipment are being added to increase production of high quality gasoline and fuel oil.

It is expected that the Fluid catalytic cracking unit being built at Gulf's Port Arthur, Texas, refinery will go on stream in September. The company reports that expansion during 1951 to meet military and civilian needs will cost $200 million as compared with 1950's $130 million expenditure.

Portuguese Grant Extended

Government decree has extended the exclusive concession held by Sacor for oil refining in Portugal to December, 1976, according to news dispatches. One-third Sacor interest is owned by the Portuguese government and two-thirds control is held by private interests, mostly French. The company is required to carry out a pre-approved plan for complete re-equipment of its refinery within the next 30 months.

Pan-Am Southern Plans High Octane Gas Expansion

Expansion of Pan-Am Southern Corporation's refinery at Destrehan, St. Charles Parish, La., is designed to add nearly 300,000 gallons a day to national production of high octane gasoline. New facilities include a Fluid catalytic cracking unit, an alkylation unit, a hydroformer unit, steam generating facilities, miscellaneous tankage and other associated auxiliaries.

Upon completion of this construction, estimated to take about 14 months, the refinery will have a capacity of 20,000 barrels a day of coastal crudes, and will produce approximately 294,000 gallons daily of aviation gasoline, 42,000 gallons of aviation jet fuel, and about 125,000 gallons of kerosine and diesel fuel, according to Roy J. Diwoky, Pan-Am executive vice-president.

The project is approved by the PAD which issued a "certificate of necessity" for construction.

Engineering at Sao Paulo Awarded Hydrocarbon, Inc.

Hydrocarbon Research, Inc., has been commissioned to supply the engineering and equipment for a 20,000 barrel-a-day refinery to be built by private capital at Sao Paulo, Brazil. The plant, which is being built by the newly organized Refinaria E Exploracao de Petroleo Uniao, will have a Thermofor catalytic cracking unit, and will be Brazil's fourth refinery.

Hydrocarbon also designed the 45,000 barrel-a-day refinery being built at Cubetao, near Santos. Both plants will be able to run either Venezuela or Middle East crude.

Refinery Engineering to Handle Kanotex Projects

New facilities and additions to existing facilities at the Kanotex Refining Company's plant at Arkansas City, Kansas, will be handled by Refinery Engineering Company of Tulsa. The new facilities will include a 4600 barrel-a-day UOP Fluid catalytic cracking unit and a 5700 barrel-a-day vacuum unit for catalytic feed preparation. Additions will be made to existing vapor recovery and catalytic polymerization facilities and a cooling tower for condenser water will be added. Crude capacity will be increased from 8500 to 12,000 barrels a day. Construction will begin this June and continue until June, 1952.

Houdriflow Unit on Stream

A 13,000-barrel-daily Houdriflow catalytic cracking unit now in operation at the Salt Lake City refinery of Salt Lake Refining Company, is the largest Houdriflow unit to go on stream to date and is circulating catalyst at the rate of 300 tons per hour by means of the new gas-lift.

Refinery Expansion by Million Barrels Daily Held U. S. Need

Special to THE WALL STREET JOURNAL

SAN ANTONIO — The nation must add 700,000 barrels a day to its basic crude oil refining capacity by the end of 1952 and a million barrels by the end of 1953.

Bruce K. Brown, deputy administrator of the Petroleum Administration for Defense, brought this measure to the Western Petroleum Refiners Association in convention here yesterday.

By the end of 1956, Mr. Brown said, new basic refining capacity must exceed 1,600,000 barrels a day. If possible, he said, these goals will be reached without recourse to special loans under the Defense Production Act or to government-owned plants. New construction will be encouraged by tax amortization and material priorities.

Basic refining projects already approved from the standpoint of tax certification, the deputy administrator noted, will require the investment of $318 million of private funds and will increase national petroleum refining capacity by 370,000 barrels a day.

"Unless and until P. A. D. is convinced the necessary expansion of basic refining capacity cannot be accomplished by normal methods," Mr. Brown declared, "it will not recommend special loans under the provision of the Defense Production Act. Such taxpayers' money as is available should, we believe, be used for necessary projects which offer smaller hope of attainment by normal methods of finance."

Mr. Brown added the goals he named for the next few years "may be insufficient if international tensions increase."

Besides finished products of the type normally needed, Mr. Brown said: "There is also a highly pressing need to increase our capacity to produce special military products, such as jet fuel and aviation gasoline, and to produce critically needed products such as benzene." Such production, he noted, is dependent on the desired increase in basic capacity, however.

At present, he said, there is a special need for greater dispersal of refineries into safe interior locations.

REFINERY EXPANSION by 1,000,000 BARRELS DAILY is NATION'S NEED...

"The nation must add 700,000 barrels a day to its basic crude oil refining capacity by the end of 1952 and a million barrels by the end of 1953." So states the article on the left.

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THE SUBJECT of aviation fuels is becoming increasingly important in the light of the present world situation. As the defense program increases in scope, more and higher-grade aviation gasolines and jet fuels will be required. In the event of another World War, still more of these materials will have to be produced to satisfy military demands.

A summary discussion of aviation fuels is presented, giving their compositions, and availability.

U. S. Navy photo shows American planes being loaded for shipment to Atlantic Pact Allies.

PETROLEUM REFINER
MAY, 1951

Trends in The Use of Aviation Fuel

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THE AVIATION FUEL picture has changed radically since the "end" of World War II. Utilization of the turbo-jet engine by the military for both fighter and bomber aircraft, as well as the probable adoption of this type of engine for some types of commercial aircraft, has introduced the problem of supply of large quantities of fuel material differing radically in properties from that formerly classed as aviation fuel.

In addition, the quantity demand for the higher grades of aviation gasoline has increased and will undoubtedly increase more in the future because of the expansion of the military forces under the defense program.

Aviation Gasoline Blends

During World War II, 100+ octane aviation gasoline (essentially the present 100/130 grade) was supplied as the combat-grade fuel for both fighter and bomber engines. Military transport and commercial planes were fueled with the standard 91 octane aviation gasoline and the lower octane grades. Near the end of the war some higher grade aviation gasoline was produced, but only a relatively small quantity was used.

In the postwar period further developments in production of aviation gasolines having better performance characteristics, and improvements in aircraft engines have enabled the adoption of the 115/145 grade for all conventionally-powered combat aircraft. In addition, a major portion of the military transport aircraft is fueled with this grade. Most commercial aircraft engines now require the 100/130 grade of aviation gasoline. This means that over-all quality demands of avia-

TABLE 1
Aviation Gasoline Characteristics 1944[b] and 1949[c]

GRADE	1944			1949			
	73	91	100	80	91/98	100/130	115/145
Aniline Point, °F.				143—146	136—140	147—153	155—158
Calorific Value, net, Btu/Lb.	18,000—18,500	18,000—18,700	18,500—18,700	.....	.....	.....	.....
Distillation, ASTM, °F.:							
10 percent	158—168	158—168	158—168	145—150	147—150	148—152	147—153
50 percent	212—221	212—221	212—221	191—197	192—198	202—207	209—212
90 percent	257—300	257—275	257—275	236—242	233—241	245—246	243—250
Freezing Point, °F.	—(—76)	—(—76)	—(—76)	.....	.....	.....	.....
Gum, (accel.) mg/100ml.	5—6	5—6	5—6	.....	.....	.....	.....
Gum Inhibitor, Lbs./5000 gals.	0—1	0—1	0—1	.....	.....	.....	.....
Octane Number:							
Lean Mixture	73	91	100	80.1—80.5	92.8—93.4	ion. + (0.13—0.15)	.....
Rich Mixture	.....	.....	.....	.....	98.6—98.9	.....	.....
Performance Number:							
Lean Mixture	.....	.....	.....	.....	.....	104.8—105.9	116.7—118.2
Rich Mixture	.....	.....	.....	.....	.....	130.6—131.2	145.8—148
Reid Vapor Pressure, psi.	6.0—7.0	6.0—7.0	6.0—7.0	6.3—6.6	6.3—6.5	6.3—6.5	6.3—6.5
Sulfur, percent	0.05—0.10	0.05—0.10	0.05—0.10	0.015—0.017	0.017—0.019	0.016—0.07	0.018—0.030
TEL., ml./gal.	1.0	4.0	3.0—4.0	0.0—0.15	2.77—3.29	3.36—3.70	4.35—4.54
Viscosity Centistokes at 70° F.	.....	.....	.....	0.592—0.604	0.591—0.606	0.604—0.618	0.606—0.619

TABLE 2
Aviation Gasoline Blending Components

Component	Clear O.N. ASTM-CFR Motor	SOURCE	
		Materials	Processing
Aviation Naphtha	65—75 65—80 76—82	Natural gas Crude oil Cracking stock	Absorption-Fractionation Fractionation Catalytic cracking Acid treating
Isopentane	90—95 90—95	Natural gas Refinery gas	Absorption-Fractionation Absorption-Fractionation
Neohexane	90—95	Ethylene, isobutane	Thermal Alkylation
Cumene	99	Propylene, benzene Hydroformate	Catalytic Alkylation Hydroforming and Fractionation
Triptane	0.07*	Isooctanes + hydrogen Propylene, isobutane	Demethylization Catalytic Alkylation
Alkylate	88—91	Isobutane, butylenes, propylenes, pentenes, isopentane	Catalytic Alkylation
Hydrogenated Polymer	80—90	Butylenes, isobutylenes	Selective Catalytic Polymerization and Hydrogenation

* Isooctane + *ml TEL/gallon.

tion gasolines are much higher than they were a few years ago.

Comparison of the characteristics of the aviation gasolines produced during the last war and presently produced is given in Table 1. From this table it is apparent that the present aviation gasolines compared to the former grades have: a) improved antiknock or performance quality; b) a lower and narrower boiling range; c) a lower sulfur content, and d) a higher lead susceptibility, requiring less tetraethyl lead per gallon for the same performance quality. All other properties are comparable with those of the wartime gasolines in the comparable grades.

Composition of Aviation Gasolines

The former top grade of aviation gasoline consisted of a blend of a stable base stock aviation naphtha, high antiknock (or performance value) hydrocarbon materials, high antiknock, medium vapor pressure stock, and tetraethyl lead. The present aviation gasoline consists essentially of the same type of mixture. However, improvement in the quality of some components, development of commercial production of other components, and the over-all higher quality of the finished product have changed the proportion of the blending components utilized.

Table 2 lists the principal types and sources of blending components used in the higher quality aviation gasolines.

During the last war all of the components listed from the sources indicated were utilized in the manufacture of aviation gasoline. Postwar conversion to meet the demand of the expanded civilian motor gasoline market and the very-much reduced aviation gasoline market diverted many of the high octane components from aviation gasoline.

Table 3 lists the major components used in compounding present aviation gasolines as well as typical composition ranges for the various grades. While alkylate represented approximately 35 per cent by volume of the 100/130 grade aviation gasoline produced during World War II, roughly twice that amount of the same grade alkylate is required for the 115/145 grade with the same blending components. With utilization of higher quality base blends and the addition of other high performance blending components, this quantity can be decreased somewhat. However, more and higher-grade alkylate is still required for the top grade of aviation gasoline.

Manufacture of Aviation Gasoline Components

Aviation Naphtha

Aviation naphtha is a hydrocarbon base stock obtained by fractionation of stocks having suitable characteristics. Natural gasoline and topped crude oils from certain sources furnish suitable base naphthas.

The characteristics desired in aviation naphthas are

Boiling range—100° - 350° F.
Sulfur content—0.00 - 0.05 percent
Octane number—65 minimum
Olefin content—negligible
Vapor pressure—less than 7.0 psi.

The desired properties require that the naphthas be derived from crudes and natural gasolines which have 100 to 350° F. boiling range cuts of relatively high octane number. Usually the suitable base stocks are fractionated to boiling range and then desulfurized if necessary to meet the low sulfur specifications.

Catalytic gasolines from the Fluid, Thermal, Houdry, or Houdriflow catalytic cracking processes make excellent aviation naphthas provided sufficient treatment is given the stocks to remove all of the olefins resulting from the cracking reaction. Usually the gasoline portion of the cracked product is fractionated to boiling range and then the fraction is given a sulfuric acid treatment. This removes the olefin compounds which make the stock unstable with regard to oxidation and gum formation. Sulfuric acid treatment also desulfurizes.

The antiknock or performance quality of catalytic base aviation naphthas is much higher than that obtainable from straight run fractions. This is the result of a higher percentage of paraffin isomers produced in the cracking reaction. Thus, there is a slight reduction in the quantity of alkylate necessary in the blend when catalytic aviation naphtha is used in place of straight run naphtha.

Isopentane

Isopentane is added to aviation gasoline to enable the blend to meet vapor pressure specification without distortion of the volatility characteristics of the finished gasoline. Although its use is not required in all blends, large quantities have been used because of its high antiknock value.

Isopentane is recovered by close fractionation of any stock in which it is contained in sufficient quantity to make its recovery feasible. Natural gasoline serves as the principal source. Distillate products from crude stabilization and from catalytic gasoline stabilization provide a source of isopentane. In many cases it is necessary to desulfurize the isopentane cut to meet specifications.

Neohexane

Neohexane, 2, 2 dimethyl butane, is a moderate vapor pressure hydrocarbon having a high octane number and good rich mixture characteristics. It

TABLE 3
Composition Range-Aviation Gasoline Blends—Percent by Volume

BLEND	GRADE 91/98			GRADE 100/130			GRADE 115/145		
	A	B	C	A	B	C	A	B	C
Naphtha 65-80 O.N.	60—80	.....	30—50	30—50	.....	20—30	10—20	20—30	.....
Acid-Treated Catalytic Naphtha—78—85 O.N.	.....	60—80	20—40	.....	30—50	20—30	.....	.....	20—30
Isopentane 90—95 O.N.	10—15	10—15	10—15	10—15	10—15	10—15	5—10	5—10	5—10
Alkylate A 102/129—105/138	10—30	10—30	.....	30—50	30—40	25—40	.....	.....	.....
Alkylate B 110/140—125/160	.....	.....	.....	.....	.....	.....	50—70	30—40	30—50
Cumene	.....	.....	.....	.....	.....	10—15	.....	10—15	.....
Triptane	.....	.....	.....	.....	.....	.....	.....	.....	5—10
ml TEL/gal.	2.5-3.5	2.5-3.5	3-4	3-4	3-4	3-3.5	4-4.5	4-4.5	4-4.5

has been produced by thermal alkylation.[20] It is also present in alkylate stocks produced by catalytic alkylation processes.

Diisopropyl

Diisopropyl (2,3 dimethyl butane) is a compound having a high octane number, high blending octane number, excellent rich mixture response and a suitable vapor pressure for replacing or reducing the quantity of isopentane needed in aviation gasoline blends.[1,10] This compound can be produced by catalytic alkylation of ethylene and isobutane using a liquid aluminum chloride-hydrocarbon-complex catalyst.[28] It can also be produced from the same feed material with a boron trifluoride-water-hydrofluoric acid catalyst.[4]

Triptane

Triptane (2,2,3 trimethyl butane) has excellent characteristics for an aviation gasoline blending component. It has good rich mixture response, high blending octane number and other qualities necessary for high antiknock blending components.[12] It is even proposed as a reference fuel component for rich mixture evaluation.[5]

This compound can be produced by alkylation of propylene and isobutane at high temperatures and pressures in the presence of small amounts of organic promoters,[24] by alkylation with sulfuric acid and hydrofluoric acid catalysts, and by selective demethylization of mixtures of 2,2,3- and 2,2,4-trimethyl pentanes in the presence of hydrogen and a nickel or a cobalt catalyst.[8]

Cumene

Cumene (isopropyl benzene) is an important aviation gasoline blending component because it greatly improves rich mixture performance of aviation gasolines with which it is blended and it has a high blending octane number.

It can be recovered from hydroformate[14] by extraction and distillation. It can also be formed by catalytic alkylation[16] of propylene and benzene in either the vapor phase, using phosphoric acid as a catalyst, or the liquid phase, using sulfuric acid as a catalyst.

Xylidines

The xylidines (aromatic amines) can be used as additives in aviation gasoline blends to the extent of 1 to 3 percent to improve the rich mixture response. Kunc, et al.,[12] report blending octane numbers of 220 for xylidines blended with 87 octane number base stocks.

These compounds are produced[21,6] by high-pressure hydrogenation of products from the nitration process. It is reported that aviation gasolines containing xylidines in the amount of 1 to 3 percent fulfill all specifications.

Alkylate

Alkylate is the principal blending component in aviation gasoline since it imparts the major antiknock or performance quality to the blend. Quantity and quality of alkylate in the blend influence greatly the performance characteristics of the finished gasoline.

Alkylate consists of a mixture of isooctanes, isoheptanes, and isononanes. In general, the greater the proportion of isooctanes present in the alkylate the better the performance quality.[21,22]

Alkylate is produced[2,11,19,21,22,27] by reacting propylene, butylenes, and pentenes with isobutane in catalytic reactors using sulfuric acid or hydrofluoric acid as a catalyst under closely-controlled conditions of temperature, concentration, and time. The alkylates produced from the processes are essentially saturated isoparaffin hydrocarbons and require no further treatment other than fractionation.

Alkylate blended into the 115/145 grade of aviation gasoline is essentially the isooctane mixture resulting from the alkylation of butylenes with isobutane. This is necessary to produce the rich mixture performance required for this grade. Alkylates produced from the lighter and heavier olefins can be used in reasonable quantities in the 100/130 grade of aviation gasoline.

Hydrogenated Polymer

Hydrogenated polymer (or hydrogenated dimer and co-dimer) serves as a high octane blending stock in aviation gasoline. It has a high rich mixture response and good lean mixture performance.

It is produced by selective polymerization[7,15] of butylenes and isobutylenes and subsequent catalytic hydrogenation[26,29] of the olefin isooctene mixture to isooctanes.

Turbo-Jet Aviation Fuels

In the past few years the efficiency of turbo-jet engines has been improved to the point where their use, particularly in military aircraft, has proved feasible. The higher speeds, approaching the sonic range, have definite military value for fighter aircraft. Undoubtedly, bomber aircraft will be powered in the near future with engines of this type for the same reason. Some European commercial air lines have ordered turbo-jet planes[23] and if they are proven to be satisfactory for commercial transport, other airlines will probably start using them.

TABLE 4
Specifications for JP-3 Jet Fuels[31]

	JP-3 MIL-F-5624
Aromatics, Vol. percent, max.	25
Bromine Number, cg/gr, max.	20
Corrosion, Copper Strip, 212 °F.—3 hrs.	None
Distillation, ASTM, percent evap., °F.	
90 percent min.	400
End Point, max.	600
Percent Loss, max.	1.5
Percent Residue, max.	1.5
Freezing Point, °F., max.	−76
Gravity API	48–62
Gum, Accelerated, mg/100 ml., max.	20.0
Heating Value, Net, Btu/lb., min.	18400
Inhibitor*, #/3000 gal., max.	1.0
Mercaptan Content, Wt. percent max.	0.005
Reid Vapor Pressure, psi.	5–7
Residue by Air Jet, ASTM, max.	10.0
Sulfur, weight percent, max.	0.5
Viscosity, cs at −40 °F., max.	0
Water Tolerance	Immiscible

* Permissible inhibitors: UOP 3, duPont 22, Shell 2,4M6B, Ionol.

Because of the nature of the turbo-jet engine, the fuel required to operate it differs greatly from the aviation gasolines used in the reciprocating type engines. The major differences are in the boiling range and in the complete lack of antidetonation or antiknock requirements for the jet fuels.

Characteristics of Jet Engine Fuels[18,32]

Turbo-Jet fuels should fulfill requirements with regard to performance as follows:

a) Maximum combustion efficiency
b) High calorific value
c) Maximum economy (minimum fuel consumption)
d) Minimum of corrosion effects (low sulfur content)
e) Minimum deposit forming tendencies
f) Suitable atomization characteristics
g) Low freezing point
h) Low vapor pressure.

These requirements are not all compatible. Maximum combustion efficiency requires a fuel which will atomize readily and vaporize rapidly for complete mixing with air. This means in most instances a volatile fuel; that is, one having the general characteristics of gasoline. Volatile fuels on the other hand have higher vapor pressures and are not suitable for aircraft having a very rapid rate of climb. Under this condition the fuel temperature does not decrease proportionately to the decrease in atmospheric pressure at higher altitudes. This introduces vapor lock problems when a volatile fuel is used for operation of jet engines. It also causes excessive evaporation losses. The lighter fuels have lower freezing points and viscosities while the heavier fuels have higher freezing points and viscosities. The former characteristics are more desirable.

The lighter fuels have higher heating values per pound and less heating

value per gallon than the heavier fuels because of the decrease in calorific value and increase in density with increasing molecular weight. From a military standpoint a greater heating value based on weight is more desirable while from a commercial airline standpoint the fuel having a greater volumetric calorific value is more desirable.

Table 4 lists the principal current specifications on turbo-jet engine fuel.

Examination of the specifications indicates that in general a stock having a boiling range from 100° to 600° F. may be utilized for turbo-jet fuel provided freezing point and stability requirements are met. Thus, a stock resulting from topping almost any crude oil, including the light naphtha, heavy naphtha, kerosene distillate or light fuel oil, and gas oil cuts could be given a light desulfurization treatment and supplied as jet fuel.

Manufacture of Turbo-Jet Aviation Fuels

The manufacture of jet fuels which will comply with the present specifications is relatively simple and requires no special refining methods or refining equipment. A conventional topping plant capable of topping crude oil with an overhead product or blend of distillate streams having an end point of 600° F., will produce a stock fulfilling the specification. Possible exceptions are those plants operating on high sulfur or highly aromatic crudes. Under these conditions it is possible that desulfurization would be necessary to enable the stock to meet sulfur specifications. If the distillate contained a high percentage of aromatics, it might be difficult to meet the freezing point specification without treatment to reduce the aromatic content.

The specifications allow inclusion of of some cracked distillate (5-10 percent) in the jet fuel product. Cracked gasoline and cracked gas oil could be included in small amounts, although normally it would not be feasible to use cracked gasoline because of its greater octane blending value in motor gasoline.

As noted above, a kerosine distillate with some lighter material added to give the desired starting volatility will serve satisfactorily, and this probably represents the best compromise fuel available.

Availability of Aviation Fuels

Table 5 lists the aviation gasoline quantities produced yearly since 1940.

The peak production of aviation gasoline during World War II, 1945, amounted to approximately 15 percent of the crude oil refined. Just after the war the quantity produced fell to approximately 1 percent and slowly increased to approximately 2½ percent during 1950. Undoubtedly a further increase in military demand because of the operations in Korea and the expanded defense program will be seen in the near future. The quantity of production is not the whole story with regard to aviation gasoline. At the peak of production during World War II the combat grade aviation gasoline consisted of the 100/130 grade and the military transport and commercial aviation used grade 91 and lower. At the end of the war, grade 115/145 became available. In 1946 the demand for grade 115/145 in relation to grade 100/130 was around 1 to 5. In 1947 it became approximately 1 to 3. Since most combat aircraft and many of the military transport planes require the 115/145 grade, it can be assumed that the proportion is much higher at present. In addition, practically all commercial aircraft operate on the 100/130 grade instead of the lower quality fuel used during the last war.

TABLE 5

Aviation Gasoline Production, 1940-1950[37, 38]

(THOUSANDS OF BARRELS)

YEAR	100 Octane and Above	Other Grades	Total
1940	643	4,727	5,370
1941	.....	.....	21,110
1942	27,678	26,848	54,526
1943	62,044	44,179	106,223
1944	136,130	60,253	196,383
1945	124,215	28,180	152,395
1946	5,342	20,070	25,412
1947	17,823	17,429	35,252
1948	33,462	12,925	46,387
1949	35,215	11,891	47,106
1950	38,542	11,881	50,423

Alkylate is used as the basis for both grades of aviation gasoline. In general, it requires twice as much alkylate to make grade 115/145 than to make grade 100/130. In addition, the quality of alkylate must be higher for the 115/145 grade than for the 100/130 to meet the specifications.

This high quality alkylate must result from processing essentially pure butylene and isobutane feed stocks. Mixed feeds including propylenes and pentenes with isopentane produce alkylates which have difficulty in meeting rich mixture performance characteristics demands for the 115/145 grade. Thus, the quantity of high grade alkylate capable of being produced depends upon the supply of butylene-isobutane feed stock available. Increased catalytic cracking capacity has increased the potential C_4 supply and probably will be sufficient in the event of a national emergency, if the quantity demands do not greatly exceed those in 1944-1945.

Aromatic blending agents such as cumene will increase the quantity of 115/145 grade aviation gasoline on the average three barrels for every barrel of high grade aromatic blending component.[2] At present aromatics are not available in the quantity necessary if our high grade aviation gasoline demands become as great as they were during the last war.

With respect to jet fuels no production figures are readily available. The supply problem should not be critical since the average barrel of crude oil will supply approximately 0.5 barrel of jet fuel provided present specifications are not made more restrictive with regard to boiling range or quality. In an all-out war it is possible that the demand for jet fuel could represent 15 to 20 percent of the crude oil produced. This is possible because it is estimated[2] that a jet engine will consume approximately three times the quantity of fuel (in pounds per horsepower hour) than the conventional reciprocating type aviation engine.

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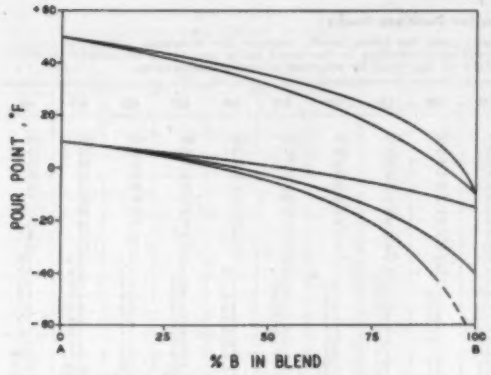


Figure 1. Typical Pour Point Curves of Distillate Blends.

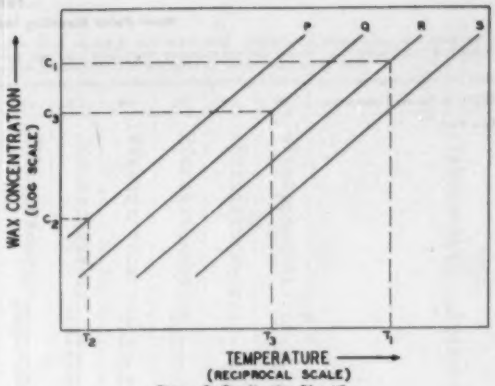


Figure 2. Qualitative Plot of

$$\text{Log } C = -\frac{A}{T} + B$$

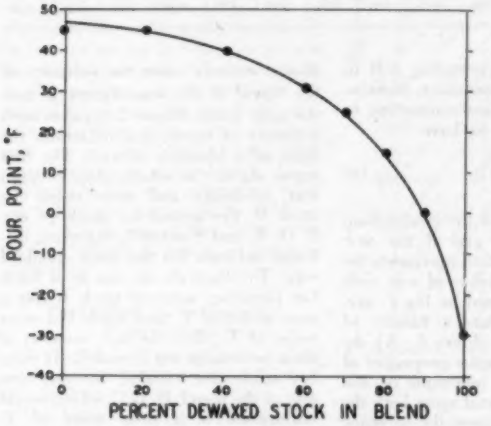


Figure 3. Pour Point Blend Curve Waxy Gasoil with Some Stock Dewaxed.

Estimating Pour Points of Petroleum Distillate Blends

EUGENE B. REID and HOWARD I. ALLEN
California Research Corporation, Richmond, Calif.

IT IS FREQUENTLY necessary in refinery operations, stock forecasts, and stock studies to estimate the pour points of blends of distillate stocks when the pour points of the component stocks are known. The problem has always been a troublesome one, and never within the authors' knowledge, has a general systematic method for calculating the pour point of blends been published. Multicomponent blends, in particular, have been difficult to handle, and reliance has been placed on rule-of-thumb methods that are usable in a routine situation but wholly inadequate for stock studies, predictions, or refinery blending when there is a variance in the stocks.

A calculation method presented here was developed through a thermodynamic consideration of the principles involved. The accuracy of the estimated pour point is of the same order as the experimental reproducibility of the pour point tests.

OCCASIONS frequently arise in refinery operations, stock forecasts, and in refinery stock studies when it is necessary to estimate the pour point of a blend of petroleum distillate stocks such as stove or diesel oils when the pour points of the component stocks are known. Very little has been published in the literature on how this might be done. The procedure presented here, developed by California Research Corporation, has been found to be reliable and convenient.

The approach used in developing the procedure is of interest since it illustrates the application of theory to a problem involving one of the many empirical tests used in the petroleum industry. Almost always in studies involving these empirical tests it is necessary to make a statistical analysis using a large amount of data. However, if the problem can be theoretically analyzed, even if not rigorously and exactly, and the proper variables determined, a framework can then be established into which data may be fitted and evaluated with a great deal more facility.

Figure 1 shows some typical binary pour point-composition curves: In general the curves are not straight lines. Pour points of the components, alone, do not entirely define the blend curve as illustrated by the upper two curves. The problem of estimating pour points is largely one of predicting the shape of these curves.

The pour point as defined by ASTM Standards on Petroleum Products, Method D97-47 is the lowest temperature in 5° intervals at which the stock will perceptibly pour in five seconds

TABLE 1

Pour Point Blending Indices for Distillate Stocks

To find the pour point of a blend, determine the index of each component from the table below, compute the weighted arithmetic average index for the blend (i.e., blend indices straight line) and find the pour point corresponding to the blend index and blend 50 percent temperature from the table. Determine the 50 percent temperature of the blend by weighted arithmetic averaging.

ASTM 50 Percent Temperature...	300	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700
Pour Point																
70	133	131	129	128	127	126	123	120	118	116	113	110	108	105	103	100
65	114	111	109	107	105	103	101	98	96	94	91	88	85	82	79	76
60	99	94	92	90	87	85	82	80	77	74	72	69	67	64	62	60
55	83	79	77	75	73	71	68	66	63	61	58	56	53	50	48	46
50	72	68	66	63	61	59	56	54	52	49	47	44	42	39	37	35
45	60	56	54	52	50	48	46	44	42	40	38	36	33	31	30	27
40	52	48	46	44	42	40	38	36	34	32	30	28	26	24	22	21
35	44	41	39	37	35	33	32	30	28	26	24	23	21	19	18	16
30	37	34	32	31	29	27	26	24	23	21	19	18	16	15	14	13
25	32	29	27	26	24	23	21	20	18	17	15	14	13	12	11	10
20	27	24	23	21	20	19	17	16	15	14	12	11	10	9.1	8.3	7.5
15	23	20	19	18	17	16	14	13	12	11	10	9.0	8.1	7.3	6.4	5.8
10	20	17	16	15	14	13	12	11	9.8	8.8	8.0	7.1	6.3	5.6	5.0	4.5
5	17	15	14	13	12	11	9.7	8.8	7.9	7.1	6.3	5.6	5.0	4.4	3.8	3.5
0	14	12	11	10	9.6	8.7	7.9	7.1	6.3	5.6	5.0	4.4	3.8	3.4	3.0	2.7
−5	12	10	9.5	8.7	8.0	7.2	6.5	5.8	5.1	4.5	3.9	3.4	3.0	2.7	2.4	2.1
−10	10	8.8	8.0	7.3	6.6	5.9	5.3	4.7	4.1	3.6	3.2	2.8	2.5	2.2	1.9	1.6
−15	8.8	7.4	6.8	6.1	5.5	4.9	4.4	3.9	3.4	3.0	2.6	2.2	1.9	1.7	1.4	1.2
−20	7.5	6.3	5.7	5.1	4.6	4.1	3.6	3.2	2.8	2.4	2.1	1.8	1.5	1.3	1.1	0.94
−25	6.4	5.3	4.7	4.2	3.7	3.3	2.9	2.5	2.2	1.9	1.7	1.4	1.2	1.0	0.80	0.72
−30	5.5	4.5	4.0	3.6	3.2	2.8	2.4	2.1	1.8	1.5	1.3	1.1	0.90	0.80	0.67	0.56
−35	4.6	3.7	3.3	2.9	2.6	2.3	2.0	1.7	1.4	1.2	1.0	0.90	0.75	0.62	0.51	0.43
−40	4.0	3.2	2.8	2.5	2.2	1.9	1.6	1.4	1.2	1.0	0.86	0.73	0.62	0.51	0.41	0.33
−45	3.3	2.7	2.4	2.1	1.8	1.5	1.3	1.1	0.96	0.82	0.68	0.58	0.48	0.38	0.31	0.25
−50	2.8	2.3	2.0	1.7	1.5	1.3	1.1	0.92	0.78	0.66	0.56	0.47	0.38	0.31	0.25	0.20
−55	2.5	1.9	1.7	1.4	1.2	1.1	0.90	0.77	0.65	0.55	0.46	0.37	0.30	0.24	0.19	0.15
−60	2.1	1.6	1.4	1.2	1.0	0.87	0.74	0.62	0.52	0.43	0.36	0.30	0.24	0.19	0.14	0.10
−65	1.8	1.4	1.2	1.0	0.85	0.72	0.60	0.50	0.41	0.34	0.28	0.23	0.18	0.14	0.10	0.07
−70	1.5	1.1	0.99	0.84	0.71	0.60	0.50	0.42	0.36	0.30	0.25	0.20	0.15	0.11	0.08	0.05

when its container is tilted. A stock may fail to flow under test conditions for two reasons: on chilling, 1) a crystalline mass of wax may set up to the extent that no distortion takes place on tilting; or 2) the stock may become so viscous that no apparent flow takes place. The pour points, limited by these two conditions, are often referred to as a "wax" pour and a "viscosity" pour respectively. With distillate stocks "viscosity" pour points are infrequently encountered, and then only at low temperatures. By limiting the discussion to distillate stocks, "wax" pours only need be considered. The situation with distillate stocks is further simplified by the lack of natural "pour depressants" such as occur in residual stocks.

Development of Method

The basic assumption is made that the pour point is the temperature at which the stock becomes saturated with wax. At this point the wax in solution is in equilibrium with solid wax, or

$$\text{Wax (solid)} \rightleftharpoons \text{Wax (solution)} \qquad (1)$$

If C is the concentration of wax in solution, the equilibrium constant for this reaction is simply

$$K = C \text{ (wax in solution)} \qquad (2)$$

From thermodynamic principles it can be shown that for ideal solutions

$$\frac{d \ln K}{dT} = \frac{\Delta H}{RT^2} \qquad (3)$$

where K = equilibrium constant
T = absolute temperature
ΔH = heat of reaction (heat of solution in this case)
R = gas constant

After integrating, assuming ΔH to be constant with temperature, combining constant terms, and converting to common logarithms, we have

$$\log C = -\frac{A}{T} + B \qquad (4)$$

where C has replaced the equilibrium constant K, and A and B are new constants. This equation represents the relationship of solubility of wax with temperature. If plotted as log C versus 1/T it represents a family of straight lines whose slopes (—A) depend primarily upon the properties of the wax and whose intercepts or displacements (B) depend upon both the wax solubility and upon the solvency of the wax-free stock.

Since "wax" is made up of a whole series of compounds, we propose that an "equivalent standard wax concentration" be used instead of actual wax concentration, and that the equivalency of wax concentration be measured by its effect upon the pour point of a standard stock. Thus, if 10 grams of a wax cause the same pour point as 2 grams of a less soluble wax, then these two amounts are equivalent and identical for our purpose and represent the same "equivalent standard wax concentration." Thus when "wax concentration" is used, "equivalent standard wax concentration" will be intended.

Considering Equation 4 again, by using "equivalent standard wax" instead of actual wax concentration, the displacement or intercept of the family of curves is essentially independent of the type of wax and depends almost entirely upon the solvency of the liquid if the temperature is now the pour point. Figure 2 presents such a family of curves and illustrates the basis of a blending scheme. The first curve shows the relationship between wax solubility and pour point for stock P, the second for stock O, etc. P, O, R, and S actually represent different solvents for the same standard wax. To illustrate its use as a basis for blending, suppose stock R has a pour point of T_1 and stock P a pour point of T_2, then the wax contents of these two stocks are C_1 and C_2. If these two stocks are blended, the wax content of the blend, Q, is C_3 which would correspond to a pour point of T_3 since the character of the blended stock is intermediate between R and P.

With this qualitative pattern or framework established from theoretical considerations, the next step is to set it up quantitatively through an analysis of pour point blend data. One of the key blends for this purpose consisted of a wax-containing stock blended with the same stock dewaxed. This blend is shown in Figure 3. These data established one of the lines of the family of curves of Figure 2. Since only pour points were measured and not wax concentrations, it is well to explain the interpretation of the pour point data. With the above blend, the amounts of wax in the waxy and wax-free stocks were arbitrarily assumed and on these assumptions the wax contents of the blends were calculated. The logarithms of these wax concentrations were plotted against the pour point, and through a process of trial

and error, the proper assumptions for wax concentrations were found which gave a linear plot.

Incidentally, it was found that a linear scale of pour point temperature gave a more nearly linear plot than a reciprocal scale. Through a similar analysis of additional pour point data, Figure 4 was finally developed. The ordinate scale is numbered with an arbitrary "blending index" but it has the physical significance of equivalent wax concentration. The parameter which adequately describes the nature of the stock was found to be simply the ASTM distillation 50 percent temperature. This characteristic apparently does two things: 1) it reflects the molecular weight of the solvent and 2) the degree of imperfection of the wax solution. Actually, if perfect solutions were formed and concentrations were considered on a molar basis, there would be only a single line on Figure 4. The crude source was found to be unimportant as a parameter, and this is to be expected from the work of Berne-Allen[1] who showed that the solubility of wax in paraffinic solvents was of the same order of magnitude as in aromatic solvents when considered on a molar basis.

Figure 4 has been reduced to tabular values and presented as Table 1. The choice in use of the chart or the table is entirely a matter of personal preference.

Procedure In Estimating Pour Points

The procedure for estimating pour points with either the chart or Table 1 is as follows:

The blending index for each component is found which corresponds to its pour point and ASTM 50 percent temperature. The index of the blend is then found by taking a volumetric weighted arithmetic average (linear blending) of the indices of the components. The pour point corresponding to this index is found from the chart or table at the 50 percent temperature of the blend. The blend 50 percent temperature is satisfactorily found by taking the volumetric weighted average of the 50 percent temperatures of the components. The method is applicable to any number of components.

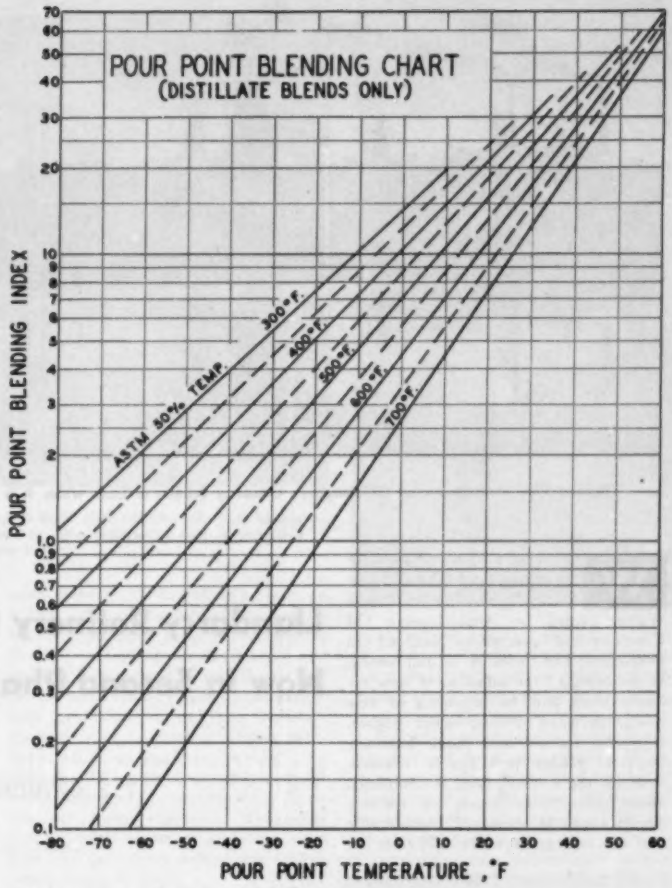


Figure 4. Pour Point Blending Chart (Distillate Blends Only).

TABLE 2

STOCK	Percent in Blend	Pour Point	ASTM 50 Percent Temp.
A	25	+30	610
B	40	0	550
C	35	−60	450

The index of the Blend is found as follows:

STOCK	Percent	Index	Fractional Index
A	25	17	4.25
B	40	5.6	2.24
C	35	0.87	0.31
Index of Blend			6.80

The 50 percent temp. of the Blend is found as follows:

STOCK	Percent	50 percent Temp.	Fractional 50 percent Temp.
A	25	610	153
B	40	550	220
C	35	450	158
50 percent Blend Temp.			530 °F.

Illustrative Example

Find the pour point of a blend of the stocks shown in Table 2.

Referring to Figure 4 or Table 1, the pour point corresponding to an index of 6.8 and a 530° F. 50 percent temperature is found to be + 2°; or rounding to the nearest 5°, the pour point of the blend is 0° F.

The 50 percent temperature is a parameter of secondary importance; hence, in cases where the 50 percent temperature of the components are not known, a reasonable assumption of these values will give a satisfactory result. This is particularly true if the difference in 50 percent temperatures among the components is not great, say 100°.

Accuracy

Out of a total of 90 blends, the pour point was predicted within ± 5° in over 90 percent of the cases. Blends included were straight run with straight-run stocks, straight run with catalytic cycle stocks, straight run with thermally cracked gas oil stocks, and catalytic cycle with catalytic cycle stocks. It is believed that the accuracy of the method is of the same order as the reproducibility of the experimental determinations.

REFERENCE

[1] Berne-Allen, A., and Works, L. T., Ind. and Eng. Chem., 30, 866 (1938).

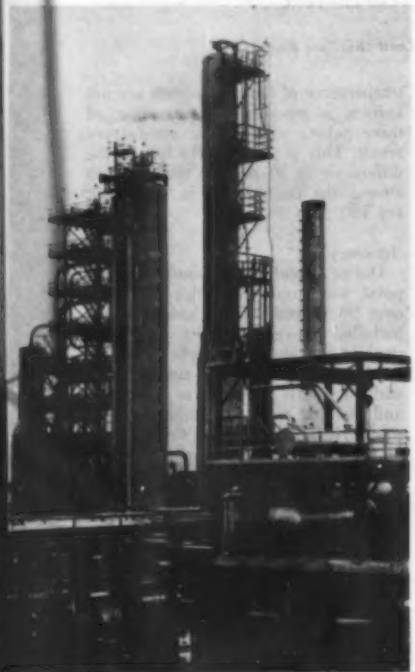
General View of Anglo-Iranian Oil Company's Llandarcy Refinery in South Wales. It is operated by National Oil Refineries, Ltd.

Llandarcy Refinery Expansion Work Now in Second Phase

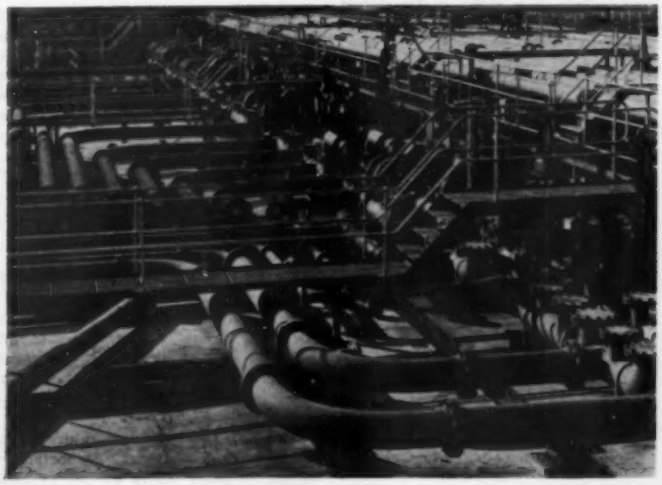
V. S. SWAMINATHAN, London

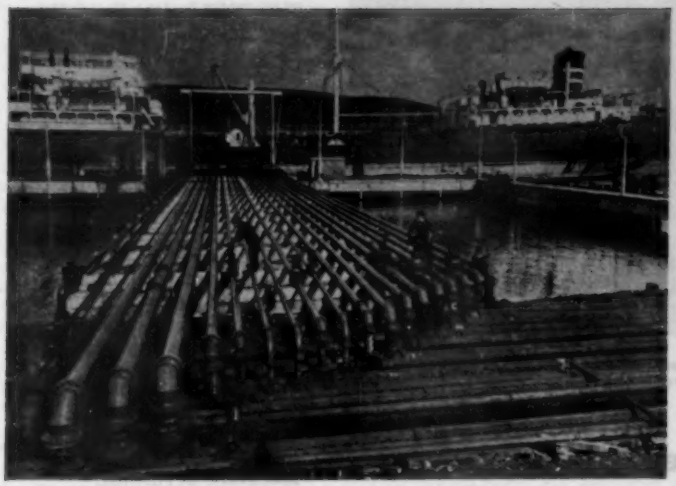
WORK on the second phase of of expansion of the Llandarcy refinery in South Wales, owned by Anglo-Iranian Oil Company and operated by National Oil Refineries, Ltd., now is in full swing. It involves, a) the addition of new refinery plant and, b) providing of new roads, railways, jetties, boiler houses, a power station and other auxiliary services. Nearest port city is Swansea.

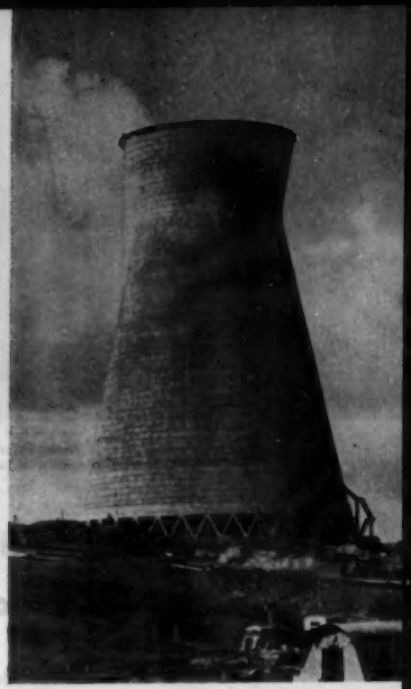
When the work in hand is completed about three years hence, the refinery capacity will be increased considerably and the enlarged refinery will turn out



On left is a photo of the stabilizer plant at Llandarcy, showing bench "B" on the left side. Pictured below is the benzene and kerosine pumphouse at Llandarcy tank farm, showing pipe manifold and spillway.







Photograph above shows one of jetties at Queen's Dock. Note offshore pipe lines leading to the jetty head and the large tanker moored to jetty. Pictured at right is completed cooling water tower.

a comprehensive range of products including propane and butane, premium gasoline, regular gasoline, kerosine, tractor vaporizing oil, various grades of gasoil, a complete range of solvent-refined lubricating oils including bright stocks, various grades of wax, fuel oil and bitumen.

Though most of the specialist plant is of American design, more than 85 percent of the equipment is being made in Britain and erected by British contractors and workmen with the help of a small team of American engineers.

The interim stage of expansion of the refinery was completed in the fall of 1949, when the 45,000 barrels per stream day crude oil topping unit and stabilizer plant, together with treatment plant and offsite facilities were commissioned nearly six months ahead of schedule. This was the first major refinery unit to be constructed in Britain after the war. Ground was prepared and the new unit commissioned in 17 months.

The refinery is operating at a crude oil throughput of some 61,000 barrels per day, turning out basic products including a large proportion of fuel oil. This provisional increase above 51,000 barrels per day was brought about by converting two obsolete continuous crackers into crude oil topping units.

To provide feed stocks for the lubricating oil line and the catalytic cracker, the vacuum distillation capacity is being stepped up by the installation of a 17,000 barrel vacuum unit. Later, a thermal reformer and catalytic polymerization plant will be set up.

Plans are well in hand and in some cases construction has already begun on a SO_2 extraction plant for kerosine, a solutizer plant for benzine treatment, a desulfurizing plant for tractor oil and gasoline and several acid washeries and return units. At all stages of the expansion program the need to maintain throughput of the existing refinery without interruption was borne in mind. The refinery site covers about 800 acres of undulating ground, ranging from 40 to 270 feet above sea level. Permissible bearing loads under foundations were found to vary from half a ton to five tons per square foot.

The tanker terminal at the Queen's Dock, Swansea, where new jetties are taking shape, was originally designed to take five 10,000-ton tankers at a time. Old timber piers are being replaced by reinforced concrete structures capable of berthing tankers of the 28,000 ton class. Three of these are now ready, and two more under way.

To deal with the refinery's increased production, extra pipe lines are being laid between the jetties and transit site. New pumps with a capacity of 4500-5500 barrels an hour are being installed. Already six stem coiled tanks with a capacity of 75,000 barrels each have been erected at the transit site to deal with heavy fuel oil. Steam to heat the tanks and lines is produced by three water-tube boilers with a total steam capacity of 85,000 pounds an hour.

The storage capacity of the main tank farm, about 3½ miles from the transit site, is to be increased to a total of close to 5,200,000 barrels by the addition of a large number of all-welded steel tanks with floating roofs. These tanks will be 144 feet in diameter and 46 feet high. On completion of the process tankage there will be some 900 all-welded tanks, representing an aggregate storage capacity of 65,000 barrels.

The main pump houses and the suction and delivery pipe system have been modernized. The main pipe routes at Llandarcy are undergoing reconstruction with more than 60 miles of the line already diverted.

Four water tube boilers each with a capacity of 150,000 pounds an hour are being installed and two more will be added later. To meet the total electrical load of 21,000 kw, a new power station with a normal capacity of 12,000 to 15,000 kw, is being added. The balance of the load will be carried by the British Electricity Authority. About 100 million gallons of cooling water daily will be required. The original 93 million gallon storage capacity is being augmented by three concrete cooling towers, each capable of cooling 15,000 gallons a minute from 120° to 80° F. The first of these towers, 162 feet in diameter and 250 high, has been in operation for more than 18 months. The other two are under construction.

The refinery will continue to use its own fuel supplies, process units and boiler houses being fired by oil fuel or refinery gas.

Meanwhile engineering workshops, fire fighting units, etc., are being enlarged and improved. Also, new laboratories and stores and modern offices to house additional supervisory and clerical staffs are being built.

General view of Process Area of Panoma Corporation Gasoline Plant, Texas County, Okla., near Hooker. Absorbers in Foreground, Dehydrators to left.

THIS PART II of the Nutter-Van Vliet description of Panoma Corporation's natural gasoline plant near Hooker, in Texas County, Oklahoma, goes into detail about auxiliary equipment. Part I, which appeared in the April issue, gave much interesting information about the process details of this plant which was carefully designed for the maximum recovery of products, minimum shrinkage of gas thruput, minimum operating and maintenance labor, etc. Operating records show a splendid result.

Authors, I. Earl Nutter and C. D. Van Vliet, are general superintendent of manufacturing, and chief engineer, respectively, of Panoma.

Panoma Plant Achieves Low Maintenance-Operation Costs

Part II. Auxiliary Equipment

I. EARL NUTTER and C. D. VAN VLIET

THE boiler house could more properly be called the power house, inasmuch as the equipment contained within the building is comparable in almost every respect with an electrical generation plant used by a utility company. This system consists of two, 50,000-pound-per-hour integral furnace-type steam generators, and supplies steam within the building to four 300-kw, 480v, condensing type turbine driven alternators. The steam is generated at 400 pounds and is superheated to around 700° F. The turbo generators and the mechanical drive turbines powering the induced draft fans of the boilers, which exhaust into the surface condensers of the turbo generators, have an exhaust pressure of approximately 1½ inches absolute, thus the electrical generation and draft in the boilers is accomplished with a very low water rate. This steam is also used at the boiler house in a mechanical drive turbine exhausting at 20 psig, to operate the boiler feed water pump. At the plant this superheated steam at 400 pounds is used in the three aforementioned oil circulation turbines, and also for generating process steam in a process steam generator and for heating gas in the regeneration systems of the propane drier and gas dehydration plant.

The boiler house is arranged with a second-story floor on which the electrical generators are installed. Also on this floor are a steam condensate receiver, a deaerating feed water heater and a triple effect feed water evaporator. All steam that goes to the plant for the various services mentioned is either returned as condensate from the heating elements or as low pressure surplus steam which is used in the triple effect feed water evaporator. The condensate from the plant, and condensate pumped from the surface condensers of the turbo generators, returns to the condensate receiver. Raw make-up water used in the boilers is first softened in a zeolite-type water softener and then automatically fed to the feed water evaporator as needed to absorb the surplus exhaust steam available. For each pound of surplus exhaust steam it is estimated that 2½ pounds of condensate, containing only 0.5 parts per million total solids, is produced as a result of its condensation and the evaporation of raw water.

All condensate produced in the feed water evaporator enters the condensate receiver, and since a surplus is always made, it is permitted to overflow to one of the cooling tower basins, which materially assists in holding down the total dissolved solids within that particular cooling system. The boilers are controlled by automatic indicating and recording fire controls, located on the second floor in the boiler house, and thus the boilers operate continuously without adjustment by the operator. A secondary set of instruments are located on the ground floor of the boiler house so that the operator may observe any interruption of operation from that point.

Cooling Tower

The cooling tower, which serves all of the cooling requirements accomplished with water in the entire plant, is of the induced draft type and consists of two sections of approximately equal size with four induced draft fans in each section. This tower is approximately 40 feet wide, 80 feet long and 30 feet high. The section on the west end of this tower cools water primarily for use in the surface condensers of the turbo generators in the boiler house, however, water from this system is also used for gas cooling at the dehydration plant during the regeneration cycle. The atmospheric type main oil coolers of the plant are located in this west section of the tower. Water cooled within the tower flows over these coils before entering the basin to be pumped to the above-mentioned services. These coils are spread over the entire area of the base of this section to serve as a distributing system on the entering air, thus good distribution of air is accomplished. The east section of the tower serves all of the shell and tube type condensers and coolers aforementioned in the fractionation system.

The induced draft fans are direct

connected to electric motors with built-in reduction gears, and with the motors being located directly over the centers of the fans in a vertical position. The motors are enclosed in circular metal housings, and air from outside the fan ducts, for their cooling, is obtained through 5-inch pipes placed horizontally across the fan ducts to support the fan and motor assemblies. These motors are two speed forward and one speed reverse to afford the desired degree of water cooling upon atmospheric changes, and to de-ice the tower during extremely cold weather. The fans and motors used on the aerial coolers in primary still vapor and lean oil cooling services are the same type as these cooling tower units except that they are not reversible.

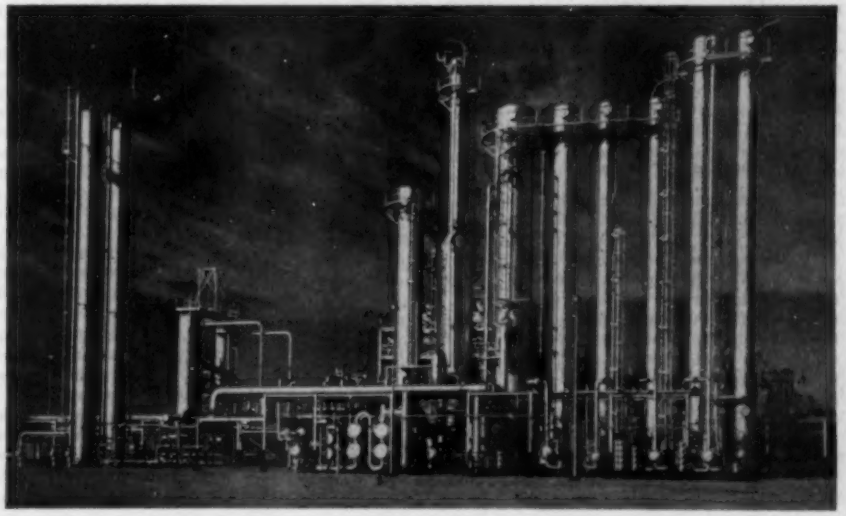
Each of the two sections of the cooling tower are equipped with two vertical turbine type water circulating pumps powered by 60 horsepower vertical hollow shaft electric motors. A fifth water pump of the same type is located between the pumps in these two services, and is so arranged that it may be used in either service as a standby without mixing the water in the two circulation systems. The water return piping from the plant to the top of the cooling tower in each of these services is equipped with a bypass line to bypass any or all of the water automatically direct to the basin of the respective sections, and is used during cold weather to maintain some established minimum temperature in the basins to prevent hydrate formation. This is accomplished by use of butterfly valves and recording temperature controllers.

The water in each of these cooling tower basins is treated with sulfuric acid and an acid inhibitor so that the total solids concentration may be carried reasonably high without encountering scale formation on the cooling equipment. The acid used for this purpose is purchased in tank car quantities and held in an acid storage tank adjacent to the railroad spur which extends into the plant yard. This tank is elevated so the acid flows by gravity to small dispensing containers adjacent to each of the cooling tower basins, where it is manually fed into the basins continuously. These dispensing containers are sufficiently small that should the entire contents be dumped into the cooling tower basin by accident, the water would not be acidized to a dangerous point. The make-up water to each section of the tower is measured by large recording roto-meter type meters. The acid dispensing tanks are graduated and the acid is added in proportion to the make-up water used. However, dosage of acid used is positively regulated by alkalinity tests made at intervals throughout the day by the operator.

The Gas Dehydration Plant

The gas dehydration plant is a dry desiccant type consisting of two towers which may be operated alternately so that one tower may be regenerated while the other is drying gas. On the drying cycle the gas is entered into the bottom of the tower through a tangential connection with the bottom section of the tower serving as a scrubber to remove particles of entrained liquid. The gas leaves this scrubber compartment of the tower and passes upwardly through a large centrally located pipe within the tower to approximately its middle section to a distributing compartment where approximately half of the stream of gas continues to go upward through a drying bed and the other portion doubles back downwardly through another drying bed, thus the gas is dried through two separate beds within the tower simultaneously. Gas leaving the tower through these separate beds is joined into a common line and passes into the residue gas header leaving the plant. The regeneration of this tower is accomplished by passing approximately 10 percent of the wet inlet gas stream to the dehydration plant through some steam heated heaters, and thence counterflow through the two aforementioned sections of the tower. This heating operation is continued until the beds are brought up to approximately 350°. The gas, leaving the tower during this heating cycle, is passed through some shell and tube type water coolers and brought back to a reasonably cool temperature. After leaving the coolers, the stream passes into an accumulator tank, where the water which has been removed from the bed by heat, and condensed from the gas by cooling, is separated from this gas regeneration stream. The gas leaving this accumulator is then admitted direct to the residue gas header leaving the plant. This stream of regeneration gas, upon mixing with the main stream of gas from the tower in drying service, results in a mixture that is within the dew point requirements of the contract.

The piping for both the drying



Frontal view of Panoma's Process Area. Main Absorbers to left, Dehydrators to left rear, Low Pressure Absorber next, followed by Deethanizer, Stills and Fractionation Channel.

cycle and regeneration cycle is equipped with block valves on all streams, and by means of pitot type flow indicators the gas may be balanced between the two beds of the tower by the setting of the valves at fixed openings. A dual temperature recorder operates on the gas temperature leaving the beds so the temperature during regeneration may be observed.

A large bypass line is arranged around the dehydration plant so that gas may be passed to the residue gas headers direct from the absorbers without dehydration. The dew point of the gas is tested on the outlet of the dehydration plant at a distance of about 100 feet. The testing may be done manually, however, an automatic dew point recording controller has been installed in the plant, which indicates the dew point at the location of this test point and transmits the record to an electronic instrument on the instrument panel within the control room some 150 feet distant. This electronic instrument is an indicating and recording controller which is calibrated to read directly in dew point. The pneumatic control phase of this instrument actuates a diaphragm valve located on a supplemental bypass around the dehydration plant to bypass wet gas and at all times maintain the dew point up to the limit specified by the sales contract. Thus, by means of this facility, the dehydration towers are not changed until this automatic bypass has just become closed and the tower on the drying cycle has reached a point where it will no longer take out sufficient moisture to meet the gas sales contract. Thus, the length of the cycle on which each tower may be operated at all times is the maximum, and it is estimated that approximately 25 percent more time of operation is accomplished during each cycle than if the system was operated conventionally on some regular time interval that was known to be sufficient to meet the dehydration requirements.

The Water System

The water supply for the plant is obtained from two water wells located within the plant yard. Both of these wells are equipped with turbine type water pumps operated by electric motors at the surface of the ground through a drive shaft extending through the casing to the pump. One well is sufficient to furnish the complete plant requirements, and each well is operated intermittently in order that they may be known to be in good operating condition. The water for plant use, discharging from the water well system, enters a 5000-barrel cone roof tank located near the boiler house. However, some water for camp use is withdrawn directly from this water well system. Water from the tank gravities to the two basins of the cooling tower and is also pumped through the zeolite water softener to the aforementioned triple effect evaporator to supply the needs of the boiler house. The tank is also equipped with an outlet system which connects through an electrically driven pump in the boiler house so that water may be had in the fire hydrants and all points in the plant by gravity through the pump while it is not operated, or at additional pressure by the operation of the pump. A gasoline-operated fire pump, taking suction from the tank, is located in the fire house some distance from all plant equipment. In the event of a complete plant failure involving interruption of the electrical system, this fire pump may be operated entirely independently for a major plant emergency. A water supply line also extends from Natural Gas Pipeline Company of America's station so that water may be obtained from this source should a fire of any duration exist and this 5000-barrel tank become empty. This interconnecting water line will also serve Natural Gas Pipeline Company in the same fashion from Panoma's source of supply.

The zeolite water softener consists of three treating towers, one of which is used to soften the water used for the camp supply enroute to an elevated domestic water tank within the plant yard. The other two zeolite softeners are used in an alternate fashion for the plant.

The Ethyl Plant

One side of the aforementioned tank car loading rack track extends through the plant fence into the plant yard. Located immediately adjacent to this track extension are the ethyl blending plant building, the sulfuric acid tank, and a 30 x 60-foot warehouse.

The ethyl blending plant is an 8500-gallon weigh tank type whereby the ethyl fluid received in tank car quantities is unloaded by gravity and pressure difference by applying a vacuum to the weigh tank. The plant is built in full conformity to the requirements of Ethyl Corporation's specifications to facilitate complete safety in the process of unloading the tetra ethyl lead and the blending of the ingredients into motor fuel. This plant is interconnected with the two aforementioned ethyl blending tanks so that both regular and premium motor fuels may be produced. The blending tanks are equipped with propeller type mixing devices and injection headers so the blends produced are thoroughly uniform.

Direct-Fired Absorption Oil Heater

The direct-fired heater, for heating the oil in the doughnut tray of the still, is located adjacent to the boiler house so that the operator may observe its operation, and to prevent it from being a fire hazard to the distillation and storage tank area of the plant. This heater is built in two sections, with the flue gases entering a common stack with dampers in the breechings so that either side may be taken out of operation and repaired. Each section of the furnace is equipped with two separate circuits of flow of 6-inch pipe size, and is capable of maintaining operation at about 75 percent of design capacity of the plant for reasonable intervals of time. These two circuits enter convection sections of the furnaces near the flue gas outlets, with one circuit obtaining radiant heating from roof tubes and the other from floor tubes of the furnace before leaving the heater. These two circuits join in a common outlet stream before combining with a like stream from the other section of the furnace in the main return line to the still. Temperature indicating controllers, pneumatically operating diaphragm control valves regulating the fuel, operate on each of these common streams separately to control the firing of the furnaces independently. The outlet of each of the two circuits of flow through each of the two sections of the heater are equipped with thermocouples and the temperatures of each stream are recorded on a multipoint electronic recorder or observed as desired on a multipoint electronic indicator located in the control room of the distillation unit. An orifice flange and control valve are located on each circuit to each section of the furnace, and by means of rate of flow controllers the flow through each circuit of each section is indicated on an indicating flow transmitter located near the orifice flange. Each of these transmitters transmit the readings to a rate of flow controller located in the control room of the distillation unit, which in turn regulates the control valve to control the flow to its respective circuit.

Since the temperature controllers control the combined streams of oil from the two circuits of each furnace, the temperatures of the two circuits are adjusted to the same temperature by manual setting of the flow by means of these rate of flow controllers.

The propane is dehydrated in a dry desiccant type system consisting of

Power-house view, Panoma Gasoline Plant. Turbine Generator Sets at right, Boiler Control and Water Level Apparatus at left, above boilers.

two vertical towers operated alternately. Regeneration is accomplished by diverting a portion of the gas from the top of the vapor reabsorber enroute to the fuel tank through steam heated units into these towers. This gas is not cooled after leaving the towers, and after separation of the water in an accumulator, goes to the fuel tank. After the heating cycle, these towers are allowed to cool by radiation to the atmosphere, since one tower is sufficiently large to operate for several days before switching to the other tower.

Electrical System

The turbines powering the electric generators operate at 4873 rpm., and by means of reduction gears these alternators operate at 1200 rpm. The manufacturer's specifications on these turbo-generators represent a water rate of about 16 pounds per kilowatt hour operating at 4-inch absolute exhaust pressure and approximately the load experienced. Although there are no means to determine water rate, it is anticipated a water rate of approximately 14 pounds per kilowatt hour is being obtained at the 1½-inch absolute exhaust. Multiple valve hydraulic governors on the turbines and automatic voltage regulators on the alternators provide maximum water rate efficiency and constant voltage output without cycle change upon sudden wide load changes. In fact, upon starting the 60-hp. electric motors at the cooling tower in water circulation service, which are the largest units in the plant, no variation in voltage or cycle of the electrical system is apparent.

The switch gear comprising instruments, generator controls and distribution panel to the plant are located on the second floor of the power house, and all electric cable to the various services in the plant is carried overhead in conduit. Through the application of capacitors at two locations near the point of demand, a 95 percent power factor is consistently maintained.

In addition to the above generators, a gasoline driven, 10 kw, light plant is located in the fire house to provide emergency lighting service.

Equipment in General

Except for the three aforementioned steam turbine powered oil circulation services, the turbine powering the boiler feed water pump and the turbines powering the induced draft fans of the boilers, all equipment in the plant is operated by electric motors. All electric motors in the hazardous area of the plant, including the motors of the cooling tower water circulation pumps, the cooling tower fans, one of the water well pumps, the motors driving the fans of the aerial coolers, and all loading pumps, are totally enclosed explosion-proof type. The remaining motors, which are located near the boiler house, are open type motors where inside, but where located outside are totally enclosed.

All pumps in the plant handling light hydrocarbons and finished production are end suction heavy duty refinery type pumps, equipped with mechanical seals, and are direct driven by electric motors connected with spacer couplings to simplify dismantling when required. Since starting the plant these pumps have operated without need of replacement of a single mechanical seal, and on only about six occasions has it been necessary to dismantle the seals to polish the seating surfaces. It appears that there is not even a vapor leak around these mechanical seals, and that there would not be a flash in the presence of an open fire. As a result of this experience with these seals, pump maintenance has been practically eliminated.

The instruments in the plant are virtually all penumatic type. In all instances of measurement with rate of flow controllers, and temperature regulation with recording temperature controllers, indicating transmitters have been located near the point of measurement and temperature control, and the recording controllers have been placed in the control room for convenient observance and regulation by the operator. The only exception is the fuel regulation of the absorption oil heater which is accomplished by indicating controllers directly operating control valves at this location. In fact, the operator can tell if any interruption occurs at any point in the plant by the observance of the instruments contained within the control room. A few electronic instruments were employed, but because they are not approved as explosion-proof equipment by the underwriters, these instruments were enclosed within a vapor proof compartment near the middle and immediately behind the instrument control panel in the control room. Glass windows were placed in the control panel so that these instruments could be observed by the operator along with the pneumatic control instruments. To service these electronic instruments, entrance to the vapor proof room is afforded by a door from the outside of the building into this room so the instruments are never exposed to any vapors that might be present within the control room. It was contemplated that should a bad failure or leak occur in the control room while an operator was servicing an electronic instrument, he would have ample time to close up the instrument before the vapors could penetrate this room.

The air supply for the pneumatic instruments, the gasoline treater, and maintenance work, is furnished by two heavy duty reciprocating type air compressors, powered by electric motors with V-built drives, located on the ground floor of the boiler house. These

air compressors are the only reciprocating type equipment in the entire plant. Each of these air compressors is capable of furnishing the needed air supply operating 50 percent of the time. They are arranged with pressure-stat unloading devices, which, while not pumping air, hold open the suction valves of the compressor and permit the machine to coast, thus preventing the continual starting and stopping of the electric motor. These pressure-stat unloaders are set so that should one machine fail, the auxiliary machine will come on automatically, without attention from the operator, when the air pressure falls 5 pounds below the kick-on pressure of the operating machine. The compressor discharges through a water cooler into a volume tank, and then into a dry desiccant type air drier. From the air drier the air passes through a filter to remove any particles of the desiccant that might be carried away by the air. This air drier consists of two vessels, with one being operated while the other is being regenerated. A steam coil is contained in each of these drier units, and in order to regenerate, the bed is heated and air is blown through by a small outside blower. After the drier has been brought up to temperature, it is closed in, and, by auxiliary connections on the steam coil, water is passed through to cool the temperature of the bed back to normal.

All piping in the plant, except drain lines, the fire hydrant system, and the suction lines to the product loading pumps, is above ground on pipe stanchions. The plant was laid out to afford extension in size without disturbing its balance or appearance. It would be possible to add additional absorbers, an additional dehydration plant, additional fractionators, and many other phases of the plant, without it being obvious that the plant was not originally so laid out. The equipment is so located with respect to distance and prevailing wind direction as to afford the greatest safety aspect with respect to fire hazard, and yet be very convenient to operate.

Another interesting feature of the plant is the method used for generation of stripping steam for the still. The stripping steam is produced in a stripping steam generator, which is a reboiler type unit equipped with a tube bundle, wherein high pressure steam is passed through the tubes and evaporates water, collected in the make tank and fractionators, in the shell. An orifice plate is located on the stripping steam line and a recording transmitter indicates the volume produced and transmits to a recording flow controller inside the control room, regulating a control valve controlling the withdrawal of high pressure condensate steam from the tube bundle, thus regulating the volume of stripping steam. Steam at 400 pounds and 700° F. is applied at full pressure to the inside of the tube bundle. In order to de-superheat this steam and cause it to start condensation immediately upon entering the tubes of the tube bundle, a jet is employed to recirculate a small stream of this high pressure steam condensate into the stream of steam entering the bundle. Otherwise, the removal of this superheat would consume several square feet of surface in this bundle before effective heating is accomplished. There are two prime advantages in the use of this stripping steam generator; first, the use of high pressure steam from the boilers without contaminating its condensate returned to the boilers with any oil or foreign matter, which would cause considerable damage to the tubes of the integral furnace boilers; and second, the re-use of the same water for stripping in a semi-closed system over and over again, thus returning any oil or hydrocarbons contained in these condensates to the stream of oil within the still. This system also fully eliminates any need for a separation system common at most plants for the removal of oil from condensate.

Both manual and automatic shutdown devices are incorporated in the plant. The manual shutdown system consists of three strategically located stations, at each of which are located two 3-way pilot valves. From any one of these stations an operator may shut off the fuel gas and simultaneously introduce snuffing steam into the fire box of either the direct fired rich oil heater or the boilers.

Automatic shutdown protection is provided for in three distinct systems:

1) A mercury switch installed near the bottom of the absorption oil surge tank will protect the pump taking suction from this source in case of a dangerously low level. Since the pumps are turbine driven, this is accomplished by simultaneously sounding an alarm and venting the air supply line to the two rate of flow controllers on the discharge of this pump so as to shut it in.

2) An abnormally low discharge pressure on the direct fired heater circulating pump will automatically shut off the fuel supply to the heater and block the steam supply to the turbine driving this pump. This automatic system is interconnected to the manual shutdown system previously described.

3) Protection to the still is provided so that water cannot enter through the stripping steam connection and cause a violent expansion. This is accomplished by the installation of a mercury switch on the stripping steam generator which will shutdown the motor of the charge pump feeding this system. As an added precaution, an accumulator is installed in the steam outlet line from this generator, on which a kidney-type float is installed. If water enters this accumulator it will cause the float to mechanically close a valve on the outlet of this tank.

As previously mentioned, all reboiler heating is accomplished with low-pressure steam. This steam is obtained at two plateaus from the exhausts of the turbines on four different services. The turbine driving the secondary lean oil charge pump is a 400 hp. unit, exhausting at 50 psig., and the other three turbines have a combined horsepower rating of 428 hp., exhausting at 20 psig. The debutanizer reboiler utilizes the 50-pound steam, but since it is superheated as exhausted from the turbine, an injector introduces a small amount of its 50-pound condensate back into the steam entering this reboiler. All excess 50-pound steam, all of the 20-pound exhaust steam, as well as the 400 and 50-pound condensate, enter a 20-pound steam flash tank containing three heat exchange trays. Here sufficient high pressure condensate flashes to de-superheat these two streams of exhaust steam to produce 20-pound saturated steam and condensate at this pressure. The steam leaving this drum is used in the remaining three reboiler services of the fractionation system, and the balance is condensed in the triple effect feed water evaporator.

In order that the 20 and 50-pound steam headers may continually operate at these pressures regardless of the varying supply and demand of the equipment tied into these headers, a system of pilot-operated regulators has been installed which cascades additional steam, if it is required, from the 400-pound through the 50-pound, then to the 20-pound headers. If, however, the steam demand of the 50-pound header is less than that supplied to it by the turbines, this surplus is relieved to the 20-pound header, where, if it is not required, it is relieved to the triple effect evaporator.

Extremely good housekeeping is practiced in all phases of this plant, and, as a result, the possibility of accidents is reduced to a minimum and the morale of the employes is exceedingly good. The fact that no lost time accident has occurred since the plant started, a period of about 900 days, is evidence of these conditions.

End of Part II and series.

New Development in Radiant Heating For the Petroleum Industry

C. C. TATE

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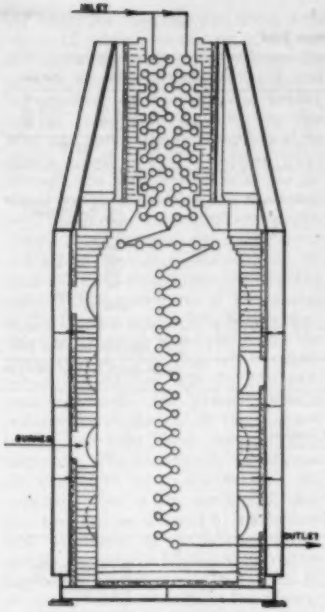


Figure 1. Cross Section and Flow Diagram of Radiant Furnace Unit No. 12.

THROUGH continuing research, two separate investigations have developed information which resulted in the commercial application of a new type of radiant heat source for petroleum processing.

The first investigation consisted of an extensive series of semi-commercial tests to determine the best thermal method of cracking a catalytic cycle oil, in order to produce a low aniline number gas oil. Tests included single-pass, two-pass, and recycle cracking at varying temperatures and pressures.

The second test program resulted from a study of the various catalytic feed preparation methods for the Borger refinery, which indicated the probable production of a high viscosity paraffinic vacuum residuum, amounting to approximately 12 liquid volume percent of the crude and representing a large volume of low value product when cut back to fuel oil viscosity specifications. Pilot plant tests indicated that for high destruction gas oil cracking and for visbreaking vacuum residuum a radiant heater designed for short residence time, uniform heat transfer and some control of the shape of the heating curve was required.

About this time two articles were published—one by J. H. Rickerman[1] and another by L. A. Meckler[2]—both of which mentioned that a flameless ceramic cup burner had been developed as a radiant heat source for refinery heaters, allowing any desired shape of the time-temperature heating curve of the oil. As a result, a demonstration of the ceramic cup burners was witnessed and, subsequently, a 30 million Btu heater was purchased for the Borger refinery.

THE SELECTION and operation of heaters has always been a major consideration for the refiner. The refining industry is continually looking for a more effective and cheaper means of satisfying the heater requirement for both old and new processes. Through the development of refining methods more time, effort, and money have probably been spent on heaters than any other one part of the integrated equipment that goes to make up a refinery.

Original presentation was at the 1951 meeting, San Antonio, Western Petroleum Refiners' Association.

Description of Furnace and Burners

The new heater was shipped in two sections, namely radiant and convection, and was installed in a very short time and minimum cost. The heater is constructed with the radiant coil placed midway between the sides as shown in *Figure 1*. The radiant section is 38 feet 6 inches long, 5 feet wide, and 12 feet high (inside dimensions). The convection section is 38 feet 6 inches long, 2 feet 3 inches wide, and 6 feet 7½ inches high. Total ground area covered is 860 square feet.

The oil enters the furnace at the top and splits into two parallel streams which pass through the forty-two tube convection section counter-current to the flue gases. The convection tubes are on equilateral triangular spacing and the rows are alternately three and four tubes wide. After leaving the convection section, the streams are joined and pass through a six tube shock section and then pass down into the radiant section. The 31-tube radiant section consists of two rows of tubes staggered so that the oil travels a zig-zag path down to the outlet at the bottom of the furnace. All tubes are 3½ inches o.d. x ½-inch wall. The convection tubes are 7 percent chrome while the radiant tubes are 9 percent chrome. Welded return bends are used throughout.

Type of Burners

Fifty-six ceramic burners are mounted in each wall—each burner independently controlled, each cup projecting heat uniformly over an area overlapping the areas serviced by the adjacent burners. The type of burner as shown in the top of **Figure 2** is rated at 375,000 Btu. per hour with a spud pressure of 6.2 pounds. The gas is premixed with air by means of an air blower and an Askania ratio controller. This air-gas mixture is approximately 225 Btu. per cubic foot when it issues from a spud at the entrance of the burner and entrains sufficient additional air to dilute the mixture to 100 Btu. per cubic foot. This 100-Btu. gas is thoroughly mixed and passes through 24 grooves around the ceramic tip of the burner. The 24 grooves issue radially into a ceramic

cup. The cup is so shaped that the numerous small flames wipe the inner surface of the refractory plate and heat it to incandescence, at a reported temperature of 2400° F. As a result of this high cup temperature and intimate mixing, optimum conditions for complete combustion exist.

The principal materials of the radiant cup burners are refractories. Material of the burner tip has to withstand a temperature difference over 2000° F. from one end to the other. The material of the cup, being instantly and constantly in contact with the gas flame, must be of such quality as to be readily brought to incandescence, in order to produce the full effect of radiation shortly after combustion is started. These refractories have proved themselves durable and it is understood that tests are still being made to find a material which will withstand a temperature of 3000° F. and higher.

Due to the simplified design and construction features, the various sections of the furnace are especially accessible for maintenance work. Due to the fact that some idea of the coking limits had to be established for each charge stock, this furnace has on occasion been fired at extremely severe conditions. In spite of this, the original brickwork in both the radiant and convection sections is still in excellent condition, and no maintenance has as yet been necessary or is anticipated.

TABLE 1

Radiant Furnace Test

	Top	Bottom
1. Firebox Temperature		
Maximum	1490 °F.	1580 °F.
Minimum	1390 °F.	1575 °F.
Average	1425 °F.	1580 °F.
2. Stack Gas Temperature	712 °F.	
3. Coil Temperatures and Pressures:		
Inlet	117 °F.—780 psig.	
Inlet 21st N	507	
Inlet 21st S	518	
Inlet 27th	648	
Inlet 35th	805	
Inlet 39th	875	
Inlet 45th	943	
Outlet	—500 psig.	
58th tube skin temp.	1295 °F.	
4. Charge	121 barrels per hour 33.8° API	
5. Fuel Fired	39,400 cubic ft. per hour H/C* 3.66	

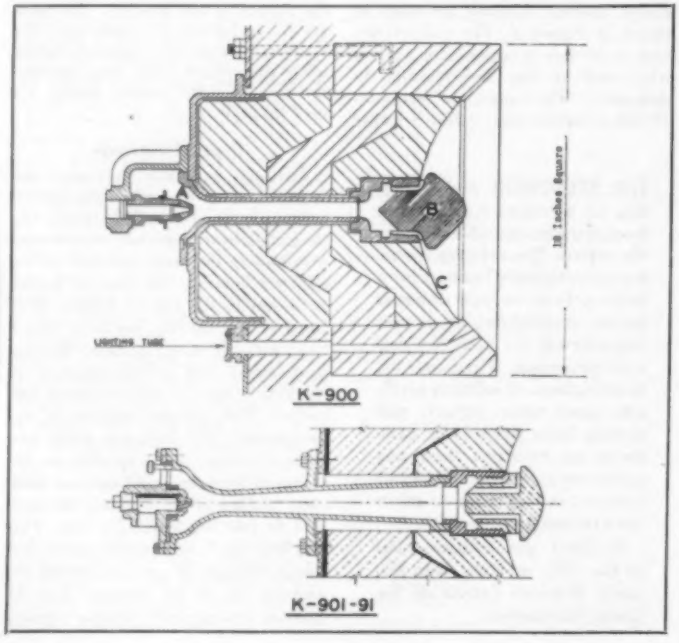
6. Orsats: (Mass Spectrometer Samples).

Average of 14 Samples	
CO_2	10.85
CO	.20
O_2	2.05
N_2	86.90
Percent excess air	9.2
H/C*	3.66

7. Heat Balances Based On Gas Side:	
Heat released by flame	38.2 x 10^6 Btu./Hr.
Heat pick-up by oil in furnace	29.48 x 10^6 Btu./Hr.
Over-all efficiency (LHV)	81.5 percent
Heat pick-up by oil in radiant box	22.2 x 10^6 Btu./Hr.
Average radiant rate	17,000 Btu./Hr. ft.^{2}
Percent useful heat	75.3 percent
Heat pick-up by oil in convection bank	7.28 x 10^6 Btu./Hr.
Average convection rate	4,920 Btu./Hr. ft.^{2} (a.d.)
Percent useful heat	24.7 percent

* Hydrogen-to-carbon ratio

Figure 2. Cross Sections of Radiant-Type Burners.



Furnace Operation

Since the start of operation every stillman who has had contact with the furnace is pleased by the ease with which it handles in variable high velocity winds prevalent in the Borger area; they have reversed their opinion that the smoothest furnace is the one which fires with over 100 percent excess air.

The operation of the furnace has been followed closely and a typical test while cracking gas oil is shown in Table 1, which discloses:

1) Average radiant heat transfer rate is 17,000 Btu. per square foot per hour,
2) Average convection heat transfer rate is 4,920 Btu. per square foot per hour,
3) Heater efficiency—81.5 percent.
4) Excess air in stack—9.2 percent.

The Orsat analyses were checked by running duplicate samples on a mass spectrometer. The tests disclosed that the east end of the furnace was operating with less than 1 percent excess

air while the west end was firing with about 15 percent excess air, giving an average at the stack of 9.2 percent. To account for the difference, it should be reported that the east end header box is completely sealed while the inlet and outlet piping as well as eight return bend thermocouples pass through the west header box. No attempt has been made to seal the opening. Sealing at these leakage points should further improve test results.

Firebox temperatures seldom exceed 1550° F. even under severe firing rates. The temperatures at the bottom of the furnace are slightly higher than those at the shock tubes just below the convection section. This low-box temperature combined with the low percent of excess air present should reduce the oxidation of the furnace tubing and tube sheet material considerably. The economy of low excess air also shows up in the fuel bill. An approximation of the savings in dollars that can be effected by the reduction of excess air is shown for a specific furnace in Figure 3. By reducing the excess air from 100 percent to 10 percent on a 30 million Btu heater, using 15 cents per million Btu gas, a yearly saving of $15,600 can be realized on gas consumption alone.

A new radiant cup burner of the totally inspirating type (*Figure 2*, burner K-901-91) has been developed and installed in several radiant heater installations in our refineries. This development has eliminated the air blower, Askania ratio controller, as well as the controls and safey devices necessary with air-gas premixing equipment. Operation of the totally inspirating burners has been very satisfactory. Contrary to the author's pessimistic predictions, the totally inspirating burners operated with no trouble at wind velocities as high as 40 mph. A general view of both the totally and partially inspirating burners is shown in *Figure 4* of two of the radiant heater installations at the Borger refinery.

Since the burners have no moving parts there is no maintenance problem. The burners light easily and burn uniformly and require practically no attention from the operator.

The dampers and design of the stack breeching give excellent control of the draft. The draft is uniform in all parts of the furnace and there is no channeling of flue gases so that the flow of gases over the tubes is uniform.

The header boxes on both ends of the furnace are bolted on and give excellent sealing of air from the ends and are easily removed for access to the return bends or replacing tubes if required.

With all welded return bends the coil is easily adapted for burnout and decoking time is reduced to a minimum which increases the actual on stream time of the unit.

A split tube should cause little firebox fire damage in view of the low excess air.

All refractory in the furnace is readily accessible and easily removable so that replacements may be easily made.

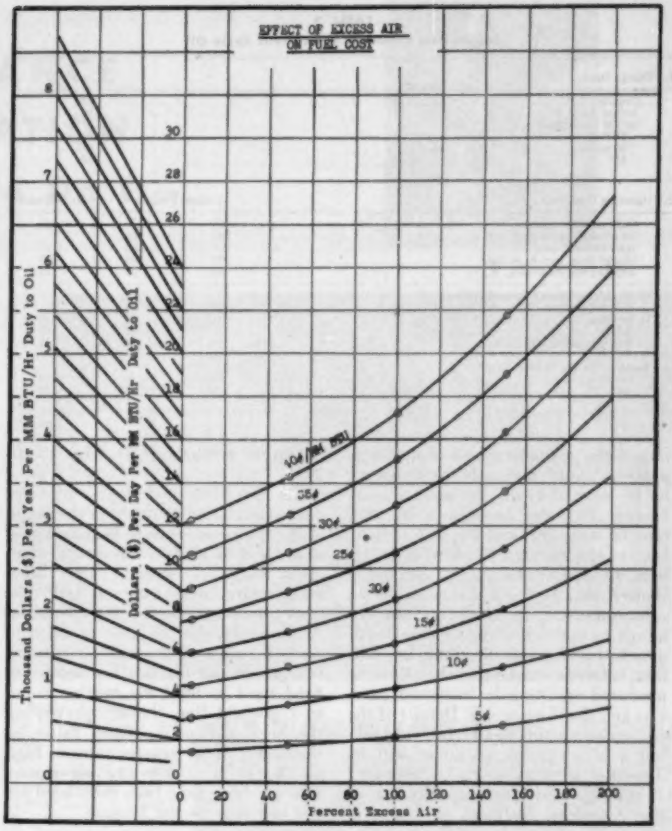


Figure 3. Effect of Excess Air on Fuel Cost.

Commercial Operating Results

a) *Gas Oil Cracking*

Although the radiant heater was purchased primarily for the vis-breaking of a vacuum reduced topped crude, it was decided to start up on a light gas oil product from a once-through gas oil cracking operation. This was especially interesting since the same charge stock was being thermally cracked on a once through basis in a box furnace designed and constructed in 1933.

In general, it was found that on single-pass cracking of both catalytic cycle oil and virgin gas oil, the radiant heater obtained conversions (gasoline + gas) of 40-50 volume percent and higher without excessive coil coking. In addition, the radiant heater yielded a gasoline having a research octane rating of four to six units higher than is normally obtained from thermally cracking a similar charge stock with the Borger refinery conventional heaters.

Table 2 shows the effectiveness of the radiant furnace in increasing cracking severity and improvement of gasoline octane ratings and yields over the old-type box furnace. It was not possible within the coking limits on the box furnace to reach the conversion levels obtained on the radiant heater. Comparable trends in conversions and results have been obtained charging virgin gas oil stocks.

b) *Visbreaking of High Vacuum Petroleum Residuum*

The visbreaking of a heavy resid-

TABLE 2

Single-Pass Cracking of Catalytic Cycle Oil

1. Charge Stock:			
Gravity, °API			33.9
Aniline Point, °F.			156
ASTM Distillation:			
IBP			436
50 percent			550
EP			669
2. Operating Conditions	**Radiant Furnace**		**Box Furnace**
Coil Outlet Temperature	1025		920
45th Tube Temperature, °F.	948	934	
Inlet Pressure, psig.	700	600	1100
Charge Rate, barrels per hour	100	100	300
Aniline Point Reduction, °F.	30	37	35
3. Yields, Liquid Volume Percent of Charge:			
Gas, mcf per hour	51.9	32.7	
Gasoline	31	28	22
Gas Oil	41	54	57
Fuel Oil (300 SFV @ 122 °F.)	10	9	12
4. Gasoline Quality (RVP—4.5):			
Research, Clear	73	71	66
+3cc.	86	84	80

uum from a high-vacuum distillation process would normally be expected to be very difficult because of coil coking, but the processing of this type of stock through the new radiant heater was accomplished with excellent results. Visbreaking operations showed that fuel oil yields could be substantially reduced over those obtained by cutback of the vacuum residuum to fuel oil specifications. In addition, catalytic cracking feedstocks were produced resulting in increased gasoline and distillate yields. Details of the utilization of this heater for visbreaking a high-vacuum residuum will be discussed in a paper to be presented at the Midwest Regional Meeting of the American Institute of Chemical Engineers at Kansas City, May 13-16, 1951.

The flexibility and degree of freedom available in controlling the shape of the time-temperature heating curve is utilized to its full advantage when visbreaking. A straight line time-temperature curve with no "tail" has been found suitable for this operation. Accordingly, the top row of burners on both sides of the radiant furnace is shut off and the last few tubes are fired hard to hold the heating curve to a straight line, thereby preventing the heat of cracking from flattening the curve. Heat transfer rates as high as 30,000 to 40,000 Btu per square foot per hour have been calculated for the last tube in the furnace.

Conclusions

By way of summation, it can be said that this type of radiant heat source gives the refiner a high efficiency furnace that is easily installed; has low maintenance and fuel costs; gives smooth operation with high wind velocities and is capable of successfully processing a wide variety of charge stocks, due to the flexibility in controlling the shape of the time-temperature curve. This selective heat input to the radiant coils produces higher heat transfer rates than in conventional heaters, thus saving initial tube costs, reducing residence time, allowing high vapor velocities and low pressure drop.

It has not yet definitely been established that maximum conversions have been reached while processing the various charge stocks. However, the results obtained have been so impressive that several additional radiant heaters have been purchased and installed. Based on present performance, this type of radiant heater has tremendous possibilities for both the large and small refiner, not only for the thermal cracking and visbreaking of gas oils, cycle oils, and heavy oils, but also for the thermal destruction of light hydrocarbons such as ethane, propane, etc., or other applications where short residence times are essential.

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[2] Meckler, L. A., and Van Frederodorf, C. G., Petroleum Refiner, 26, 51-64, 1947.

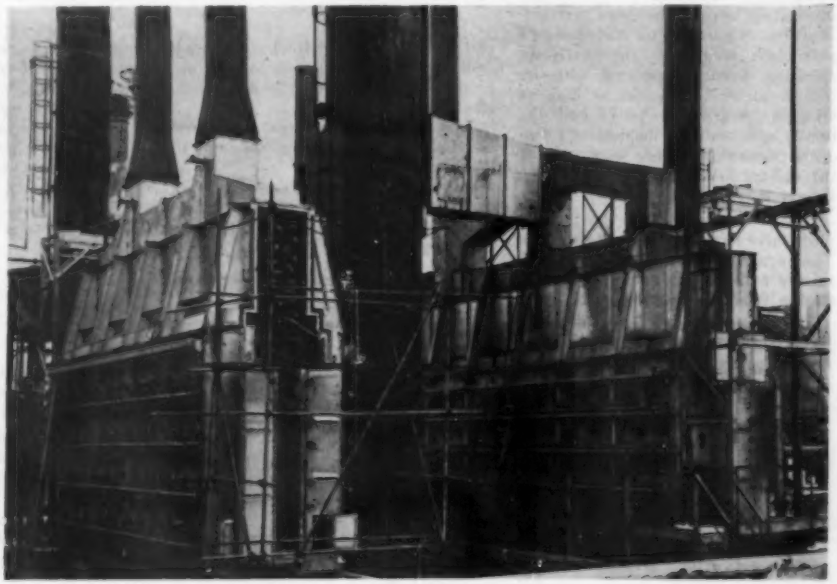
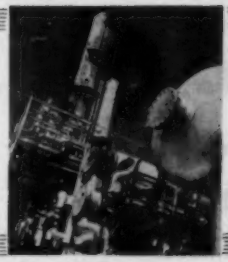


Figure 4. Two Radiant Heater Installations.

MAINTENANCE And OPERATION How To Do It—



HOW—

Sea Water Is Utilized For Cooling Loads

SOME difficult cooling water problems have been solved in a plant where it is necessary to employ recirculatory, closed water systems because ground water is not available for a once-through system. The unlimited volume of available sea water would create a serious salt corrosion problem if used directly in this way.

The two basic cooling jobs are to cool the recirculating scrubbing liquor which cools and cleanses the finished gas, and to cool the fresh water that is circulated in the jackets of the gas compressors and their prime movers.

Reformed gas passes through a closed tower for a wet scrubber type of cleansing and cooling operation in intimate contact with sprayed water. This water picks up a large quantity of heat as well as residual impurities.

The equipment used for cooling all recirculated fresh water consists of built-up batteries of cast iron cooling sections over which salt water is sprayed. These cooling sections have high resistance to salt water corrosion and have proven economical in both first cost and maintenance, particularly when there are large quantities of process solution.

The coolers were designed for a minimum of evaporative cooling in order to avoid salt incrustation. They are placed close together and are surrounded by asbestos cement walls which accomplish this and also prevent salt mist from being blown over other corrodable structures or equipment made of carbon steel. *Figure 1* shows the catch basin and enclosing structure just before completion.

The scrubbing liquor cooler is arranged in three parallel banks, each serving scrubbers for one of three cracking furnaces. The three banks are interconnected in order to provide maximum operating flexibility. There are 418 sections in each bank which has two rows of sections in series, each row consisting of 11 parallel stacks, 19 sections high.

The combined cooler with 1254 sections was designed to cool 1800 gpm. of scrubbing liquor from 140° to 95° F. when supplied with 2325 gpm. of sea water at 70° F.

The cooling of water in the compressor and engine jacket system is similar to that for scrubbing liquor. Jacket water is circulated through closed systems and cooled by means of once-through salt water. Compressor jacket water must be kept within a temperature range of 113° to 90° F. in summer and engine jacket water must be kept within a temperature range of 162° to 150° F.

There are five compressors. Two, which are driven by 2000-hp. natural gas engines, are each provided with a cooler consisting of 256 sections arranged in 16 parallel stacks 16 sections high. They cool 550 gpm. of jacket water, using 633 gpm. of sea water at 70° F.

Three compressors are electrically driven, one by a 2000-hp. motor and two each by 800-hp motors. The latter two units are cooled by 208 sections arranged in 13 parallel stacks, 16 sections high. These sections cool 630 gpm. of compressor jacket water from 113° to 90° F. using 550 gpm. of sea water.

Jacket water for the two gas engines, circulated at 1400 gpm. is cooled by 11 parallel stacks 10 sections high. Sea water flows over these cooling sections at the rate of 420 gpm. to lower the temperature from 162° to 150° F. As shown in *Figure 2*, these coolers are inclosed with coolers for the compressors which they drive.

Photos courtesy The National Radiator Company, Johnstown, Pa.

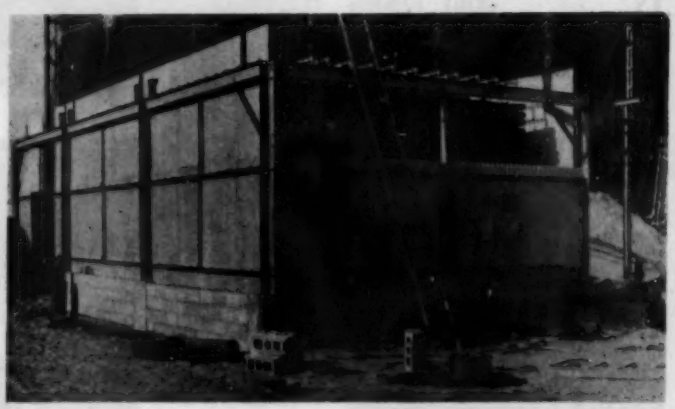


Figure 1 (above). Cooler for scrubbing liquor consists of three double banks of sections enclosed by steel-framed Transite walls. Behind cooler is a new 5-million-cubic-foot gas holder. Long Island Lighting Company, Glenwood Lighting Plant.

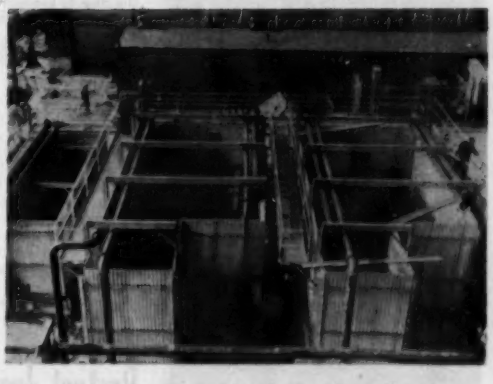


Figure 2 (right). Compartment at left is for motor-driven compressors, and the other two compartments are for two gas engine-driven compressor units. Transite walls minimize salt water corrosion of surrounding equipment.

HOW TO—

Measure Pump Performance

DYNAMOMETERS are being supplemented in the industry with new type "torque measuring" instruments. Coupled in the drive shaft, a small take-off device provides an accurate and continual indication of the torque and power delivered to pumps. A portable, self-contained indicator calibrated in foot-pounds is wired to the take-off and may be placed anywhere convenient to an observer.

Figure 1 shows an experimental test set-up for a single stage of a boiler feed pump. The purpose of this test is to improve the efficiency and performance of pumps. In this test the pump is driven by a turbine instead of an electric dynamometer.

In *Figure 2* the performance characteristics and power requirements in pumping an oil of high viscosity (one million SSU at 67° F.) is being determined. A gear pump is driven through a gear box and torquemeter shaft at speeds ranging from 50 to 200 rpm. against delivery pressures up to 600 psi. This arrangement eliminates calculations involving efficiencies of motor and gear box.

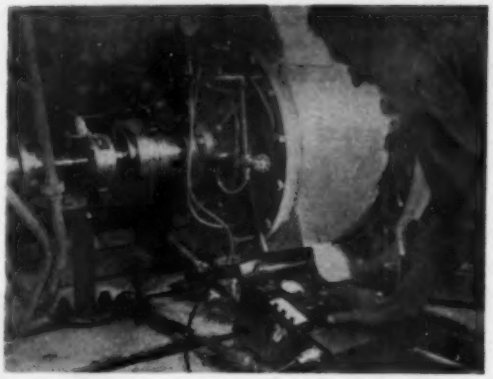


Figure 1. Measuring the torque input of a single stage of a boiler feed test pump (right) by means of a torquemeter. Strain in a short length of the drive shaft is measured by bonded resistance wire strain gages and transmitted through slip rings to a portable indicator.

Figure 2. Performance characteristics and power requirements of a gear pump for high-viscosity oils are determined largely by drive-shaft torque measurements with the torquemeter. The indicator, wired through slip rings to bonded resistance wire strain gages on the shaft, is calibrated to read in foot-pounds.

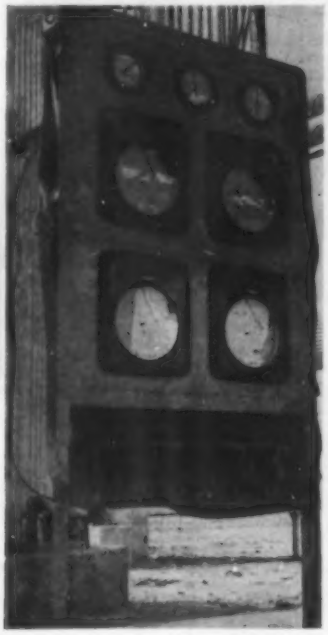
Torquemeters used in these tests are based on the bonded resistance wire strain gage, widely used in stress analysis work. The torquemeter is essentially a short length of shaft to which a group of special strain gages are bonded so as to form a Wheatstone bridge. The corners of the bridge are connected through slip rings on the shaft to stationary brushes and thence to an indicator. Horsepower, a simple function of torque and shaft speed, is readily computed. Brush friction in the instrument absorbs negligible power.

Worthington's Research and Development Department was one of the early industrial users of the torquemeter. Extensive experimental work was done to check the accuracy and dependability of the new method of measurement. This included both static and dynamic studies.

In static tests a simple, home-made calibrator was constructed. This consists of a center mounted lever arm and torquemeter mounting bracket. The lever arm extends four feet each side of the center mount, permitting loading in either direction.

Dynamic tests were made to study the character and magnitude of torque pulsations, as read on the meter, which were causing inconsistencies in some measurements. This work was done with a cathode ray oscilloscope which gave the amplified torque signal in the carrier-frequency stage of the torque indicator. It was discovered that the pattern on the oscilloscope was disturbed by stray electrical fields.

This problem was solved by grounding the drive shaft which was apparently insulated enough by the film of lubricant in the bearings to produce a high resistance to ground and thus interfere with the dynamic torque observa-



How Outdoor Instrumentation Panel can be protected from Damaging Freeze-ups.

HOW TO—

Protect Instruments From Freeze-Ups

TEMPORARY protection against cold weather freeze-up was provided for an outdoor instrument panel installation by means of a tarpaulin and improvised steam header. Heat from the bare pipe steam radiator rises in the space between the back of the panel and the tarp, effectively warming the instrument piping systems.

tion on the cathode ray screen. Grounding was provided by a flexible metal strip wiping the torquemeter shaft and held by a bracket on the case of the brush mounting unit, as shown in *Figure 1.* The case is grounded either by the stand that supports it or by a special ground wire.

Successful use of two torquemeters of 350 and 500-foot-pound capacity has led to the purchase of two more of larger capacity, 1600 and 3200 pounds, to be put in service within the near future.

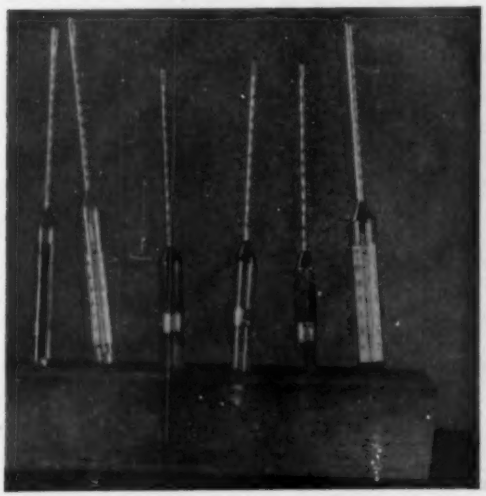
The addition of the new type torque measuring instruments was the result of work by the Research and Development Department of Worthington Pump and Machinery Corporation. Photos courtesy of Baldwin-Lima-Hamilton corporation, Philadelphia.

This device prevents damage like this

HOW—

Latch Keeps Plant Doors Open and Secure

THE operators of one Gulf Coast gasoline plant found that frequent strong breezes played havoc with glass panels in building doors. The repair bill for this single item reached a notable amount, but was eliminated by the installation of simple door latches which can hold the doors in a fully open position. As may be noted, the latches are so balanced that they hold the door securely until deliberately released by an operator's toe pressure.



An Easy-to-Make Rack that Soon Proves Its Worth in Any Plant Laboratory

HOW TO—

Make an Efficient Jacket Valve

THE steam jacketed control valve was made by welding a pipe section as shown. The pipe jacket was notched with a "U" shaped cut-out. Nipples were screwed into the valve ends and seal welded. Jacket ends and part of the scrap from the "U" cut-out were welded into place.

Such a jacket valve is pictured in the photograph which appears below.

HOW—

To Make Rack For Protection of Laboratory Hydrometers

IN ONE laboratory a simple wooden hydrometer rack serves to protect this fragile glass equipment from damage.

Before the rack was used considerable breakage was experienced in this particular laboratory.

The holes of the wood rack are tapered slightly, thus grasping the hydrometers snugly.

The device is pictured in photo at the left.

MAINTENANCE And OPERATION

How To Do It–

Performance of Cooling Equipment

HAROLD A. DRESSER

The Marley Company, Inc., Los Angeles

MANY thousands of words have been written and spoken regarding operation and maintenance of all types of equipment used in manufacturing plants or plants where heat must be removed. Too often we find in equipment where water or air is used to obtain the cooling, a tendency to disregard the operation and maintenance of the equipment doing the cooling. This reticence on the part of operating personnel to service properly the equipment can be attributed to various factors including:

a) Lack of a proper maintenance schedule
b) Failure in the part of management to insist on proper maintenance.
c) Failure on the part of management and operators to admit that cooling is most important in the plant.

Actual Cost Check

This third reason is the greatest of all. To check this, management need only look into the actual costs resulting from the loss of production or a complete replacement of the equipment as the result of poor maintenance.

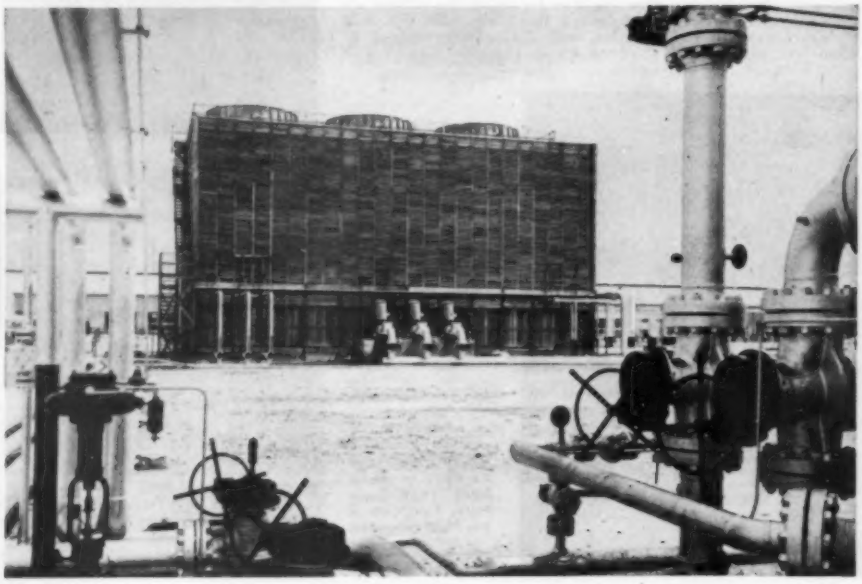
It can be assumed by an operator of a new piece of equipment that when it is turned over to him everything is in order. All the equipment in the plant has been designed and installed in accordance with information supplied by his company or a consulting company and the manufacturers. The proper operation and maintenance of the equipment in the plant, therefore, becomes his chief concern in order to obtain maximum production.

In an old plant it generally is assumed by the operators that the equipment in its original state was doing its work properly. It's a well known factor that in most old plants certain of the equipment is being over-loaded. Why is this the case? The answer to this is that all equipment has a certain factor of safety which is not the same in all equipment. Heat exchangers may have a greater safety factor than a water cooling tower or air cooling equipment. If the plant load has been increased to take up all of the safety factor of the heat exchangers then the Btu. heat load that the cooling tower or air cooling equipment must handle may be greater than the safety factor allowed for when it was installed. Only one thing can happen. The temperatures of the cooling water in the case of the cooling tower will go up. The temperatures of the products being cooled by the cooling tower will increase.

In the air cooling equipment, since the quantity of air can not be increased

THIS ARTICLE reviews the factors of importance in the operation and maintenance of cooling towers and other cooling equipment and provides a guide for the use of plant men.

View of Tower with Water Circulation Pumps.



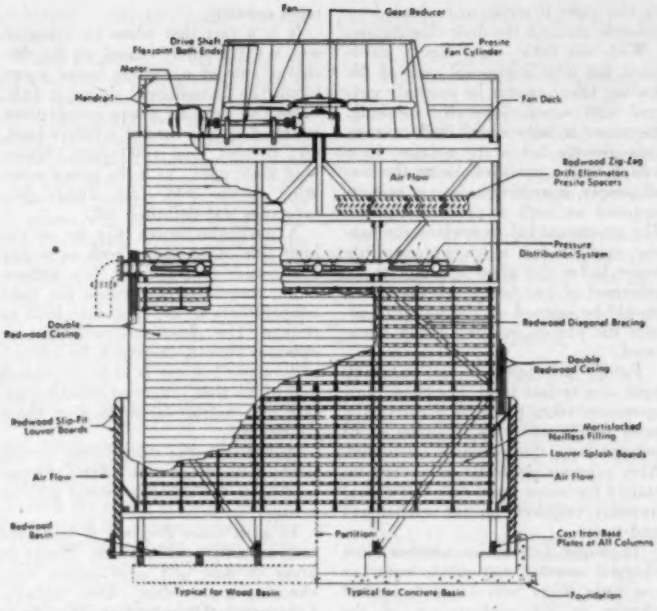


Figure 1. Sectional View of Typical Induced Draft Cooling Tower with Wood Filling Members.

beyond a certain point, temperatures of the products being cooled will increase. To offset these increased temperatures the equipment must be maintained at its highest point of efficiency.

Too often we find that certain equipment is not kept in good repair. (We are all guilty of this even in our own automobiles which have a cooling system.) Cooling is very important in any plant. The operation and maintenance of any piece of cooling equipment should, therefore, be given more consideration than it generally receives. The efficient operation of the plant therefore depends on obtaining the coldest water or product possible.

Frequently the manufacturers are blamed for not supplying maintenance instructions. This lack of instructions in most of the cases can be traced to improper handling of the requisitions for the equipment and purchasing department rules and regulations. A supplier of equipment must follow the instructions given on a purchase order. If he does not, then trouble develops.

Who ever writes the requisition, should state on his request that one copy of all papers, prints, instructions, etc. should be sent to the interested party. I would venture to say that 75 percent of the instructions which failed to reach the field will be found in the purchasing departments' files if they have not been thrown away.

Management, in view of this commonplace occurrence, should take steps to correct such practices. Management by issuing orders can change existing procedure and effect proper routing of instructions.

In the equipment to be discussed in this series, only cooling towers will be covered at this time.

Cooling towers may be classified into:

A) Atmospheric—1) spray filled; 2) wood filled; and B) Mechanical—1) forced draft and 2) induced draft.

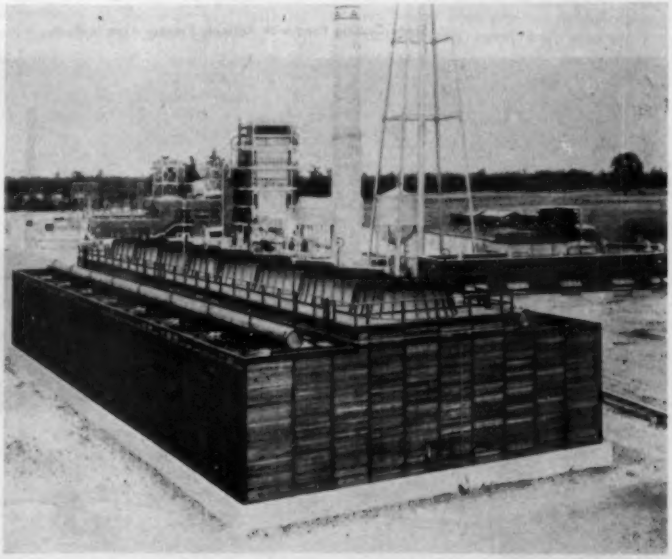
These two types can be further broken down into: 1) spray type and 2) wood fill type.

Another classification would be: A) open-type systems and B) closed-type systems.

Air cooled equipment includes forced draft and induced draft—both vertical and horizontal. Then there are evaporative coolers, atmospheric sections and shell and tube exchangers.

Maintenance and Operation

The proper operation and maintenance of any of this equipment is becoming more important every day. In the early days data governing the selection of equipment were not too accurate. To be assured of proper operation the equipment was greatly overrated or over-designed. Within the last few years, faced with ever increasing costs of labor and material, equipment manufacturers are designing and fur-



Typical Induced Draft Cooling Tower with Fans Mounted Horizontally on Roof Deck.

MAINTENANCE And OPERATION
How To Do It—

nishing equipment that instead of being 20 to 30 percent oversize is from only 1 to 2 percent and sometimes not that much.

As a result of the changes in design and rating, equipment must be properly maintained and operated to deliver what it was designed and installed to do. A cooling tower is a heat transfer device (water to air), and therefore, must be operated and maintained accordingly.

First and most important in any type of tower is proper distribution of the water. There are three general causes of improper distribution; a) dirty or clogged nozzles or troughs; b) too much water; and c) too little water. Clogged or dirty nozzles and troughs are the result of improper inspection or possibly total lack of inspection.

It is recommended that weekly inspection be made of the distributing systems. Primary as well as secondary (coil systems) also should be inspected to assure proper operation. Too much water being circulated causes improper operation.

Excessive water loss is caused by a) Wind, in the case of natural draft towers; and b) Fans, in the case of mechanical draft towers.

Damage to surrounding equipment results from excessive spray. Too much water in a pressure system increases the height of the spray causing the water to strike or be forced by pressure through the drift eliminators.

With too little water being circulated, the total horizontal area of the cooling tower cannot be properly covered with water. Generally speaking, the water is only distributed over an area directly below the nozzles. In a trough or low-pressure system the loss of proper distribution is not as pronounced as with a pressure system. The recommended procedure for taking care of too much or too little water is for the plant operator to be informed of just how much the valves should be opened on the pump to assure the proper quantity being circulated.

Pumps are selected for so many gpm. at a certain head. The head, until operation takes place, is a calculated head which may vary as much as 10 percent from that actually calculated. Also a pump generally is always installed for more gpm. than the actual quantity required on the exchangers and tower.

Improper distribution whether from clogged nozzles, too much water or too little water will cause a marked change in the performance of the tower, i.e., higher cold water temperatures will result. In towers with high final temperatures this will not mean very much, but it will in towers where close approach is desired to the wet bulb. There have been instances due to clogged nozzles and too much water combined where the approach was off 10° or instead of 70° water with 65° wet bulb it was 80° with a 65° wet bulb. The problem usually is too much water rather than less water than the rated capacity.

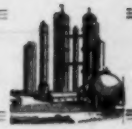
It is a fact that when an operator sees a valve partly closed on the discharge side of a cooling tower water pump, he immediately opens it full. Cases can be cited where pumps were installed to take care of a future load, viz., present load 1000 gpm., future load 2000 gpm., with the tower operating at the 2000 rate. Tower performance was definitely off.

A particular tower may be on the high side of its rating both as to fan horsepower and gpm. A few gallons more, therefore, may cause the final temperatures at the rated wet bulb to change. The plant superintendent or operator should, therefore, be advised of how much water is to be circulated and to his best judgment should regulate the control valves to meet those conditions.

Along with the distributing system next in importance to obtain proper cooling is the decking (wood fill) of a tower.

In most cases decking, if inspected semi-annually, will suffice. Plants in areas of dust and sand storms need checking more often. Also, installations near other manufacturing plants in which dust is discharged should be inspected more frequently. To keep the decks clean, frequent wash down with a high-pressure water hose is recommended. Broken or sagging wood fill members should be replaced to insure proper distribution. The water collecting basin, wood or concrete, should also be inspected weekly for excessive dirt and debris. Pit screen should be inspected weekly and cleaned as often as required. If not properly cleaned

Spray Cooling Pond with Refinery Process Area in Rear.



exchanger equipment may become clogged.

Water treatment is of utmost importance not only for keeping algae at a low point but also to preserve the life of the tower and the deposit of solids. A competent water-treating company should be employed or your own chemical department should check on the best method of treatment. No two plants will have the same conditions to combat. Weekly tests of the water for pH value should be made is possible.

Water with a pH value above 7.5 with sodium carbonates or sodium bicarbonates present will immediately cause delignification of the wood. Preventive methods should be started immediately if delignification is found. Under no circumstances should any water treatment be used which may leave an oily surface on the wood fill. If leaks occur in the exchanger equipment and the tower becomes oily the filling should be stream cleaned. Oily or slick surfaces of the wood filling increase the water loss and raise the water temperatures.

Watch for casting, bolt, and nail failures caused by improper water treatment.

In mechanical draft towers and air cooled units, the operation of mechanical equipment becomes very important. The mechanical equipment involved consists of electric motors, gas or diesel engines, gas or steam turbines, couplings, or driveshafts, gear reducers and fans. This equipment has been selected by the manufacturer to meet the operating conditions for which the cooling unit was designed.

Improper inspection and maintenance of this mechanical equipment will not only cause failures but will affect the over-all operation of the unit. Equipment out of operation may cause a complete plant shutdown or a substantial reduction in plant output.

It is recommended that all mechanical equipment be inspected as follows:

a) *Motors, gas or diesel engines, turbines*—weekly for the following:

1) Unusual vibration or noise.
2) Overheating.
3) Shaft for lateral movement.
4) Tightness of casting and bolts holding equipment in place.
5) Check keys and keyways.
6) Check oil level and oil for water and dirt.
7) Check to determine if vents are open.
8) Lubricate as recommended by equipment manufacturer.
9) Dry out if necessary, as required.
10) Repaint as required.

b) *Couplings or driveshafts,* weekly as follows:

1) Unusual vibration or noise.
2) Lubricate weekly or as specified.
3) Check for loose bolts.
4) Repaint as required.

Position of the mechanical equipment should not be changed once it has been installed. Misalignment as to elevation is necessary in some types of equipment.

Lubricant for the couplings or driveshafts should be that specified by the manufacturer, or that found best by experience.

c) *Gearboxes* should be serviced and inspected weekly as follows:

1) For unusual noises or vibration.
2) Check shafts for lateral movement. (Tip fan blade to see if there is too much lateral play in the gearbox of the fan shaft, move driveshaft laterally to determine if there is excessive play in the pinion-shaft.) This indicates whether the bearings are worn.
3) Inspect pinion shaft key and keyway.
4) Check oil level and inspect oil for dust and water. Change oil as specified by the manufacturer. Refill only with the type which meets manufacturer's specifications.
5) Check vents or vent piping to determine if open.

Check periodically all bolts securing the gearbox to the framework. Also, at the same time check the structure for tightness.

Repaint gearbox as required.

Forced Draft Equipment

In forced draft equipment the temperatures of the gear units in addition to the mechanical heat will be governed by the temperature of the air passing over the gear boxes. In the case of induced draft equipment, the temperature of the gear unit will be governed by the temperature of the air passing by the unit. In the case of cooling tower, the temperatures of the air will be approximately that of the water entering the cooling tower. In the case of an induced-draft air-cooled unit the temperature of the out going air in general should not exceed 160° F.; thus the type of oil to be used in this gear unit would be based on that temperature.

d) *Fans* should be checked periodically to determine their condition. Since the other equipment is being checked weekly, it is very easy to check the fans at the same time.

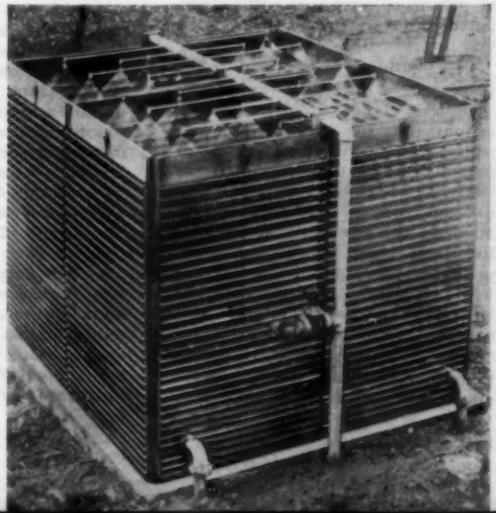
1) All bolts securing the blades should be checked for tightness.
2) Fan hub cover should be checked for tightness.
3) Hollow blades should be checked for condensed water.
4) The pitch of the fan blades should be checked semi-annually. Out of pitch fan blades will cause excessive vibration and ultimate failure.
5) If fans were painted when originally installed then they should be repainted as required.

Structural members in any piece of cooling equipment should be checked periodically for vibration and deterioration. If these conditions are found, the cause should be located and steps taken to remedy them.

Particular emphasis should be paid to the structural members supporting the gears and motors.

If oil is spilled on to the eliminators or decking when servicing the gears, it should be cleaned up if at all possible. This condition will cause excessive water loss and some decrease in cooling. The wood will also start to deteriorate.

The information presented above, if properly followed, will enable operators to better equipment performance.



Small Shower Type Atmospheric Cooling Tower.

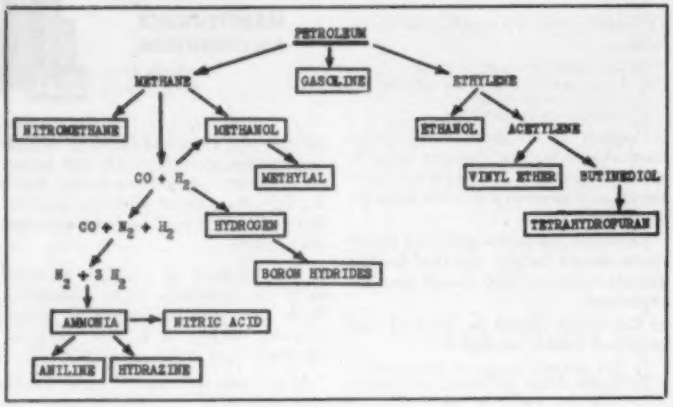


FIGURE 1

The Petrochemical Engineer Looks at Rocket Fuels

MARSHALL SITTIG
Chemical Engineer, Detroit

THE petroleum industry exists primarily to supply the liquid fuel needs of the transportation systems of the world. As these needs shift, as they already have to a degree, from reciprocating-engine fuel to gas-turbine fuel, so they may well shift again to rocket fuels. Military needs will certainly precede commercial needs for liquid rocket fuels but in any event, the chemical departments of petroleum companies will be prepared to furnish these materials as they are needed.

Research in the chemistry of rocket fuels must be directed toward the development of new propellant combinations, decreased sensitivity of propellants, and increased availability of propellants. Potential competition with essential materials in the event of a national emergency must be borne in mind. As with other materials essential for military use, standby peacetime production of promising propellants would be of great value and this might be achieved through development of non-rocket applications for rocket fuels.

This discussion will be largely confined to liquid fuels. Solid fuels in use today in military rockets are of the type of nitrocellulose and are fabricated in the form of large, specially-shaped grains, filling the entire body of a small rocket. Long-range military and commercial rockets will depend on liquid fuels or possibly on liquids in combination with some solids, such as powdered metals.

S. D. HERON has said[1] that although the gas turbine engine for aircraft will apparently not be able to obtain very considerable improvements in performance by means of developments in fuel, the same does not hold true for rockets. Heron goes on to say[1] that the rocket-type aircraft engine appears to be susceptible to improvements in performance as a result of fuel development which can be expected to exceed those which have occurred with the piston-type aircraft engine.

In view of this, the petrochemical engineer of today should possess some knowledge of those materials currently in use as rocket fuels and of those materials which are potentially attractive as tomorrow's propellants.

The requirements of an ideal rocket fuel include the following:

1) High heat of combustion
2) Rapid, almost instantaneous combustion
3) Low molecular weight
4) High density
5) Automatic starting
6) Safety in storage, transport, and handling
7) Ease of manufacture from abundant raw materials
8) Low freezing point.

As may be seen, some of these requirements conflict. A stable fuel for safe handling and one decomposing automatically and instantaneously in the rocket motor would hardly seem to be one and the same. Thus, an actual fuel will be a compromise fuel.

Liquid rocket fuels are commonly divided into monopropellant types and bipropellant types. Monopropellant systems are less common but include:

Nitromethane
Hydrogen peroxide

In such systems, a catalytic material or a small amount of oxidant are used to initiate decomposition.

Bipropellant types are more common. The classic example is the use of alcohol and liquid oxygen in the German V-2 rocket.

V-2 a Chemical Plant

The V-2 rocket was quite a chemical plant in itself. In it hydrogen peroxide was fed into a small chamber along with calcium permanganate solution. Under the catalytic influence of the permanganate, the peroxide decomposed according to the reaction:

$$2\,H_2O_2 \rightarrow 2\,H_2O + O_2$$

giving superheated steam at 788° F. and 350 psi. by direct chemical generation. This steam then flowed into a steam turbine, mounted on the same shaft with pumps which pumped 75% ethyl alcohol and liquid oxygen into the venturi-shaped main combustion chamber of the rocket. To prevent the pump (pumping 150 cfm. = 276 pounds per second) from drawing a vacuum on the huge fuel tanks, they were separately pressurized. The alcohol tank was pressurized by nitrogen bottles for a short time after take-off and then after the rocket attained sufficient speed, was pressurized by ram air from a line leading to the nose of the rocket. External pressurizing agents could not be used with the liquid oxygen however due to the hazards of explosion through the introduction of contaminants. Therefore, a

small liquid oxygen line was carried back to a heat exchanger where the peroxide-generated steam from the turbine vaporized it for return through another line to pressurize the oxygen tank.

Other bipropellant combinations than alcohol-oxygen which have been used or proposed for use include the following:

Ammonia	—Liquid oxygen
Gasoline	—Liquid oxygen
Gasoline	—Red fuming nitric acid
Aniline	—Red fuming nitric acid
Vinyl alkyl ether	—Red fuming nitric acid
Hydrogen	—Fluorine
Methanol	—Chlorine trifluoride
Hydrazine hydrate	—Hydrogen peroxide
Furfuryl alcohol	—White nitric acid
Boron hydride	—Water

Among the more radical propellants which have been suggested are fluorine monoxide in combination with molten lithium metal, a combination possessing a very high heat of reaction.

It will be noted that each of the above pairs consists of a fuel (left-hand column in the table) and an oxidizer (right-hand column in the table). The materials designated as fuels are those which fall most logically into the petroleum chemicals field although an integrated plant might produce the oxidizer as well. (See Figure 1.)

The Germans used a set of code names for the various rocket fuels and oxidants which are well to mention in passing since much of the published literature assumes that the reader is familiar with these terms. They include:

Myrol	—Methyl nitrate in methyl alcohol.
T-Stoff	—High-Strength (85-90%) hydrogen peroxide.
Perhydrol	—High-Strength (85-90%) hydrogen peroxide.
C-Stoff	—30% hydrazine hydrate, 57% methanol, and 13% water.
Visol	—One of several vinyl ether compositions: 65% vinyl ethyl ether, 11.8% aniline and 23.2% pyrocatechol, $C_6H_4(OH)_2$. —also vinyl isobutyl ether.
Sv-Stoff	—97% nitric acid.
Tonka	—A mixture of hydrocarbons similar to gasoline.
Ergol	—A mixture of: Optol (a hydrogenated lignite tar fraction), tetrahydrofuran, furfuryl alcohol and aniline.

The criterion of performance in a rocket fuel is not octane number or cetane number but is the pounds of thrust produced per pound of fuel burned per second. This is known as the "specific impulse" of the fuel and is proportional to the exhaust velocity of the gases issuing from a rocket motor. The selection of a fuel involves many other factors of course, such as density, which governs the overall size of the rocket. Some typical values of specific impulse are as follows:

Liquid oxygen—75% ethyl alcohol,	239
Liquid oxygen—ammonia,	255
Liquid oxygen—hydrazine,	246
Liquid oxygen—liquid hydrogen,	458
Hydrogen peroxide—C-Stoff,	215
Red fuming nitric acid—aniline,	221
White nitric acid—furfuryl alcohol,	214
100% hydrogen peroxide monopropellant,	145
90% hydrogen peroxide monopropellant,	131
Nitromethane monopropellant,	218

It will be noted that many of these fall in the same narrow range and that the bipropellants in general are superior to the monopropellants. The high specific impulse of the liquid oxygen-liquid hydrogen is counterbalanced by the difficulties inherent in handling the two liquefied gases and by the low density of the hydrogen, necessitating a large fuel tank.

Additives for Rocket Fuels

Just as additives are of importance in reciprocating and jet engine fuels, so will rocket fuels undoubtedly employ additives for optimum performance. An example of an application of an additive lies in the use of terpene hydrocarbons as combustion catalysts for the reaction of concentrated nitric acid with gasoline or diesel oil. This use is covered in U.S. Patent 2,489,051 by American Cyanamid Company. The addition of 20 percent turpentine to gasoline reduces the ignition lag upon mixing with nitric acid to less than one second from several seconds in the absence of the promoter.

Let us examine the methods of manufacture of some of these rocket fuels and oxidants.

Ammonia (NH_3). Ammonia is produced by the chemical departments of several petroleum companies. Natural gas is treated with steam in a catalytic reforming process to give carbon monoxide and hydrogen. Air is added to furnish the nitrogen and the oxygen in the air is burned out by a portion of the hydrogen. The mixture of CO, N_2, and H_2 is scrubbed with ethanolamine to remove the CO and give a feed gas for ammonia manufacture which contains nitrogen and hydrogen in a 1:3 ratio. High-pressure catalytic conversion of this mixture gives ammonia.

The low boiling point of ammonia (—28° F.) complicates its storage and handling. It is toxic and it corrodes copper and brass.

Hydrazine (N_2H_4). Hydrazine melts at 35° F., boils at 236° F. and has a specific gravity of 1.02. Hydrazine hydrate, $N_2H_4 \cdot H_2O$, freezes at —40° F., boils at 245° F. and is the form in which hydrazine is most commonly used as a rocket fuel. Hydrazine is produced commercially by the Raschig process through oxidation of ammonia or urea by hypochlorites. A large excess of ammonia is used, the reactants are mixed at low temperatures, and then are rapidly heated (to 320° F. at 375 psi.) to effect the formation of hydrazine from chloramine and ammonia. The reactions involved may be outlined as follows:

$$NaOCl + NH_3 \rightarrow NaOH + NH_2Cl$$

$$NaOH + NH_2Cl + NH_3 \rightarrow N_2H_4 + NaCl + H_2O$$

In addition, the following side reaction occurs:

$$2NH_2Cl + N_2H_4 \rightarrow N_2 + NaCl + 2\,NH_4Cl$$

which decreases the yield of hydrazine. Glue and gelatin are employed to suppress this undesirable side reaction.

The commercial process involves reaction, removal of excess ammonia, removal of salt, and finally removal of water by three separate distillation steps to give a constant boiling product containing 85 percent hydrazine hydrate, $N_2H_4 \cdot H_2O$.

Hydrazine vapor is extremely irritating to the eyes; the inhaled vapor causes various effects including dizziness and nausea. The vapor may cause dermatitis. Hydrazine and hydrazine hydrate are only slightly corrosive to metals however.

Aniline ($C_6H_5NH_2$). The Dow process for the manufacture of aniline by the direct reaction of chlorobenzene with ammonia is well known. The chlorobenzene may be produced from chlorine manufactured from by-product HCl from the chlorination of hydrocarbons in a petroleum chemical plant. The reaction of chlorobenzene with ammonia may be conducted at 400° F. and at pressures from 850 to 950 psi.

Since aniline has a relatively high freezing point (20° F.), furfuryl alcohol is commonly added to the extent of 20 percent in rocket fuels to depress the freezing point without harming performance. Aniline vapors are extremely poisonous.

Nitric Acid (HNO_3). The oxidation of ammonia with air gives nitric oxide by the reaction:

$$4\,NH_3 + 5\,O_2 \rightarrow 4\,NO + 6\,H_2O$$

Secondary oxidation converts the NO to NO_2 and the NO_2 dissolved in water gives nitric acid by the equation:

$$3\,NO_2 + H_2O \rightarrow 2\,HNO_3 + NO$$

The NO produced in this last step is recycled and oxidized to NO_2. Variations in the absorption technique employed in the contacting of NO_2 with

water will yield white fuming nitric acid or red fuming nitric acid (RFNA) as rocket oxidants.

White fuming nitric acid is pure HNO_3, freezes at —60° F., boils at 191° F., while RFNA contains 2 percent H_2O, 6-15 percent free NO_2 (which imparts the red color), and 92-83 percent HNO_3, freezes at —57° F. and does not have a clearly defined boiling point due to easy evolution of NO_2. Both red and white nitric acids are very corrosive and very toxic.

Nitromethane (CH_3NO_2). Nitromethane is the most attractive of the monopropellant rocket fuels. Its manufacture from natural gas by direct nitration is accomplished by methods developed by Dr. H. B. Hass and his co-workers at Purdue University and practiced industrially by Commercial Solvents Corporation.

$$CH_4 + HNO_3 \rightarrow CH_3NO_2 + H_2O$$

Nitromethane is an oily, colorless liquid freezing at —20° F. and boiling at 214° F. It finds commercial use as a lacquer solvent. It is not corrosive or toxic but is quite explosive in nature.

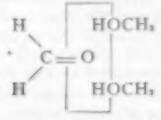
Furfuryl Alcohol ($C_4H_3O \cdot CH_2OH$) and Tetrahydrofuran (C_4H_8O). The furan derivatives may be most inexpensively manufactured from agricultural raw materials such as oat hulls, in the manner employed by Quaker Oats Company.

Tetrahydrofuran may alternately be produced from acetylene by a technique developed by Reppe in Germany in World War II. Thus, acetylene from the cracking of petroleum hydrocarbons may be reacted with formaldehyde to give butinediol, the butinediol hydrogenated to butanediol, then dehydrated to tetrahydrofuran.

Furfuryl alcohol freezes at —25° F., and boils at 340° F. Tetrahydrofuran boils at 150° F.

Methanol (CH_3OH). Methanol is made by the well-known process involving the high-pressure hydrogenation of carbon monoxide using techniques similar to those employed in synthetic ammonia manufacture which, as mentioned above, is an established process in the petroleum chemicals industry.

Methylal ($CH_3OCH_2OCH_3$). Methylal is a colorless liquid, boiling at 108° F., freezing at —155° F. and having a specific gravity of 0.86. It is the reaction product of methanol and formaldehyde in the following manner



where water is split out in the reaction.

Methylal has a high heat of combustion, a low heat of vaporization, a low boiling point, and combines these with good burning characteristics to provide a powerful fuel. Unlike most ethers, methylal does not form an appreciable amount of peroxide on standing. Since it yields methanol on hydrolysis, contact with the eyes must be avoided.

Ethyl Alcohol (C_2H_5OH). Ethanol freezes at —179° F. and boils at 173° F. Its manufacture from ethylene by catalytic hydration in the presence of sulfuric acid or solid adsorptive catalysts is well established.

Vinyl Ethers (CH_2=$CHOR$). These materials, which were known as Visols by German rocket researchers include vinyl ethyl ether and vinyl isobutyl ether. Both of these materials may be made by the German Reppe process involving the reaction of acetylene with ethyl or isobutyl alcohol, as the case may be, according to the reaction:

$$ROH + C_2H_2 \rightarrow CH_2 = CHOR$$

This reaction is carried out at 300° F. under pressure adequate to keep the alcohol in the liquid phase (60-75 psi. for isobutyl alcohol, 270-300 psi. for ethyl alcohol). The acetylene gas, diluted with 60 percent or more of nitrogen for safety reasons, was bubbled up through a solution of potassium hydroxide in the alcohol in a steel tower. The product leaving the top of the tower was fractionated to recover the vinyl ether.

Vinyl ethyl ether freezes at —175° F. and boils at 95° F. Vinyl isobutyl ether freezes at —170° F. and boils at 181° F.

Boron Hydrides (B_2H_6, B_5H_{10}, etc.). These substances are unique in that water may be used as the oxidizing agent in a propellant combination. Much work on these materials has been done by Prof. H. I. Schlesinger at the University of Chicago and work continues in Dr. Schlesinger's laboratory, under Dr. A. B. Burg at the University of Southern California, and at the Naval Ordnance Test Station at Inyokern, Calif., on these materials for rocket use.

The preparation of these materials formerly involved the reaction of magnesium with boric oxide to give magnesium boride which in turn yields boron hydrides upon hydrolysis. A more recent process involves the hydrogenation of boron trichloride, or preferably boron tribromide, with the aid of a powerful electric discharge. Hydrogen is bubbled through the boron halide and the resultant vapor mixture is passed through the discharge, after which it is condensed and fractionated.

Tetraborane, B_4H_{10}, freezes at —184° F. and boils at 64° F. It will not ignite spontaneously in the air when pure, but may do so when impure. It decomposes on heating to give diborane, B_2H_6, plus hydrogen. The reaction with water is as follows:

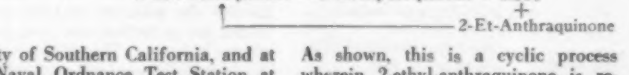
$$B_4H_{10} + 12\,H_2O \rightarrow 4\,H_3BO_3 + 11\,H_2$$

Hydrogen Peroxide (H_2O_2). Highly concentrated (85-90 percent) hydrogen peroxide was virtually unknown prior to World War II. The use of stabilizers and other handling techniques have been developed, one of the leaders in this country being Buffalo Electro-Chemical Company.

Hydrogen peroxide in 87 percent concentration freezes at 14° F. and boils at 288° F.

The usual manufacture of hydrogen peroxide involves the low-temperature electrolytic oxidation of sulfate solutions to persulfate solutions in 30-35 percent concentrations. These solutions are then evaporated to 85 percent by two-stage vacuum evaporation in the process for high-strength peroxide. Acid hydrolysis of the persulfate solution yields hydrogen peroxide.

An interesting synthesis of hydrogen peroxide which was developed in Germany in World War II and which involves an organic chemical intermediate is the following:



As shown, this is a cyclic process wherein 2-ethyl-anthraquinone is recycled. This process was developed to reduce the requirements of strategic alloys needed in the usual processes and was successful—a large plant was under construction in Germany at the end of World War II.

Tonnage oxygen, a commodity being exploited by petrochemical and synthetic fuel interests, is of obvious application in peroxide manufacture by this latter process.

Oil Progress Facts

Oil companies during 1950 invested approximately $2,000,000,000 to expand and modernize their facilities to provide more oil for America.

REFERENCE

[1] Heron, S. D., in "The Development of Aviation Engines and Fuels," Harvard University (1950).

Sweetening and Desulfurization Of Light Petroleum Products

Part VII. Vapor Phase Desulfurization

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A VARIETY of desulfurization methods are based upon the splitting of the sulfur compounds at elevated temperatures and in the vapor phase. This article explains the mechanics and chemistry of the reactions, continuing a series on the treatment of light distillates manufactured from sulfur bearing crude oils. A final article will describe sulfur removal by extraction and miscellaneous other methods.

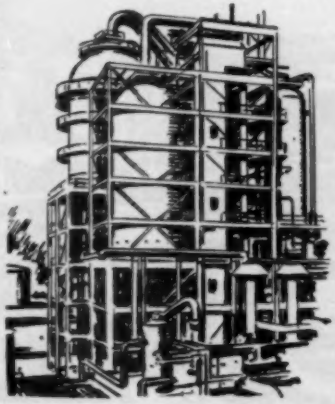
MANY of the sulfur compounds particularly mercaptans and sulfides present in petroleum are relatively unstable at elevated temperatures and have the tendency of splitting off hydrogen sulfide or react with substances like metals or metallic oxides before the hydrocarbons begin to decompose. Most of the remaining hydrogen and carbon atoms recombine and form new hydrocarbon molecules which results in a higher product yield than that obtained by the conventional desulfurizing methods involving elimination of the whole molecules. The reactions are facilitated by the presence of hydrogen taking an active part in the rebuilding of shattered structures. If hydrogen sulfide is evolved it is removed by fractionation[91] or caustic washing the condensate. It may also be separated by counter-washing the product with water which is preferable to the use of caustic because it preserves inhibitors in the gasoline.[92]

The degree of desulfurization attained in vapor phase refining depends on the nature of sulfur compounds present and the severity of treatment. Some of these compounds are very stable to heat and little affected by the catalyst or chemicals even at the temperatures of decomposition of most hydrocarbons. For this reason the desulfurizing processes cannot be compared on the basis of relative precentages of total sulfur removed unless the same charge stock is employed. Otherwise the results may indicate not the process efficiency but the quantity of refractive sulfur compounds present in the feed.

Importance of Temperature

Temperature is a very important factor in vapor phase desulfurization. For instance, by passing petroleum vapors over fullers earth at comparatively low temperatures the sulfur content of the oil remains practically unchanged although the color and the gum content are improved. However, using the same catalyst at temperatures approaching the cracking range a considerable quantity of sulfur is eliminated, but polymerization reactions leading to elimination of gum forming materials are arrested or reversed. This demonstrates that, within certain reservations, vapor phase refining might be considered as selective cracking of sulfur compounds under conditions which have only a minor effect on other oil constituents.

The beneficial effect of elevated temperatures on sulfur removal led also to the development of processes involving addition of treating agents to the oil during distillation. The suggested chemicals include clay,[41] charcoal,[53] cellulose materials,[30] wash water from citrus fruit industry,[59] alkaline reagents like sodium hydroxide[16] or lime,[63] oxidizing agents represented by compounds of manganese[23] or chromium[22] and by sodium peroxide,[20] reducing agents such as sulfites and hyposulfites,[77] acids like sulfuric[75] or nitric,[24] metals and metallic oxides having affinity to sulfur, particularly those of copper,[25] lead[21] and iron and their various combinations,[32] calcined mixtures of a mineral phosphate, superphosphate or Thomas slag and sulfuric acid[63] and arsenic.[25] Mixtures of some of these materials were recommended including those of sodium hydroxide and adsorbents,[28] sodium sulfate, sodium hydroxide and lime,[67] or sodium chloride, lime, potassium nitrate and potassium hydroxide.[70] The main object of many of these processes is the general improvement of oil quality rather than the reduction in sulfur content but a strict differentiation between these two refining purposes is not always possible. The best known desulfurizing process of the above type is that of Frasch which employed oxides of copper and related metals and was in commercial use about a half century ago.



The vapor phase refining processes came into prominence after the appearance of thermally cracked products. Some of them were intended for stabilization of cracked gasolines with respect to color and gum formation as described by Kalichevsky and Stagner[56] while others were developed for removing the sulfur compounds. A large number of substances was suggested for vapor phase treatment of light distillates but only relatively few of them are in commercial use. One of the main objections to this method of desulfurizing oils is the cost of equipment. However, this can be minimized by combining the desulfurization step with cracking or hydrogenation which also reduces the operating expense.

Use of Fullers Earth

Fullers earth was, apparently, the first adsorbent suggested for vapor phase refining of petroleum distillates[22] which found wide commercial application for improving color and oxidation stability of thermally cracked products.[56] In the Gray treating process the oil vapors from the distillation units are forced through a bed of fullers earth in order to polymerize the unstable constituents. The high boiling polymers are removed as a

liquid at the bottom of the clay tower while gasoline vapors pass to condensers.[37] The treating temperatures are low and practically all the sulfur compounds are left intact. In the Gray desulfurization process the same general method is employed but the treating temperature is raised in order to secure selective cracking of these compounds.[58] The efficiency of fullers earth in this respect is claimed to be improved by mechanically altering its physical structure.[14] In order to reduce both the sulfur and gum content of the product the two processes must be employed in sequence although the catalytic agent, i.e., fullers earth, is common to both of them.

The use of high treating temperatures results in deposition of carbon and rapid loss in clay efficiency. Success of the vapor phase desulfurizing processes is, therefore, dependent on the availability of satisfactory methods for regenerating catalysts without removing them from the unit. The same problem is encountered in catalytic cracking and was solved by the industry. The Houdry Desulfurization process employing activated clay or synthetic catalysts of silica-alumina type came into existence as an outgrowth of the corresponding catalytic cracking process. The desulfurizing properties of bauxite are utilized in the Perco Desulfurization Process.

Various modifications of the treating procedures were suggested for improving the operating technique. The desulfurizing action of clay is claimed to be enhanced by mixing gasoline vapors with those of gas oil[29] or heavy distillates[42] and similar materials.[72] A broad petroleum fraction may be vaporized, passed through the clay bed, the gasoline fraction condensed, washed with sodium hydroxide solution and recontacted with clay under the same conditions.[8] The temperature of the oil vapors may be controlled by introducing inert gas[78] or water[74] into the reaction zone and the desulfurized products fractionated.[66] Cracked gasoline vapors may be first treated with adsorbents at relatively low temperatures to polymerize the gum forming constituents and then desulfurized at

Cardon Refinery To Double Capacity

THE Shell refinery at Cardon on the Paraguana Peninsula, North Venezuela, is to have its capacity doubled to 7 million tons yearly by extensions which were started in the early part of this year. Work is scheduled for completion in 1952.

Additional facilities include another large crude distillation unit and modifications to the existing distillation unit.

Nearing completion now is a modern installation for producing more than 1740 barrels per day of high quality lubricating oils. Officials said the lube oil plant will be extremely flexible and will comprise units as follows: 1) propane de-asphalting; 2) furfural extraction; 3) MEK/benzol dewaxing, and 4) clay contacting.

Up to now the Cardon project has cost Shell nearly $140 million.

Plants at Cardon which already have been completed and are in operation include the crude distillation unit, a doctor treating plant and ethyl blending plant, a vacuum distillation plant, redistillation unit, cracked product separation plant, two thermal cracking units and a thermal reforming unit. For the storage of crude oil and finished products, 131 tanks of all sizes have been constructed.

Until recently all fresh water for industrial and domestic purposes had to be imported by tankers while drinking water was obtained by seawater distillation. Now an 80-mile pipe line brings water for all purposes from springs and wells on the mainland.

Cardon's motive power is almost exclusively electric. A power station operates with three 7500-kw generating units and another unit of the same size is being installed.

Harbor facilities include two large reinforced concrete jetties, each 1500 feet long. Four large ocean tankers and four smaller tankers may be berthed simultaneously.

The refinery area including the industrial and residential sections occupies more than 3000 acres. Extensive research is being carried on in the industrial area. The small city which has been built is self sufficient in every way. A new hospital has been projected and the old building will be utilized for further school purposes.

The intake at Cardon will consist of Venezuelan reduced crude oils, both of the mixed base (paraffinic) and the naphthenic (non-paraffinic) type. Facilities for blending, packing and filling will also be provided.

General View of Shell Refinery at Cardon on the Paraguana Peninsula, Venezuela.

considerably higher temperatures.[8] Before passing through clay the oil vapors may be mixed with chemicals like hydrochloric acid,[27] sodium hydroxide,[24] carbon monoxide,[12] sulfur dioxide, oxygen and steam[60] and others.[85] The oil vapors may be desulfurized and the hydrogen sulfide removed before they are passed to the cracking units[39] or catalytic cracking may precede the treating step.[86] The treated vapors may be freed from hydrogen sulfide and a portion of them recirculated through the catalyst.[61] Catalytic desulfurization of natural and straight-run gasolines may precede alkylation.[55] The oil vapors may also be contacted with a clay slurry[62] instead of passing them through a clay bed.

Bauxite is a satisfactory desulfurizing catalyst[2] and commercial methods were developed for preparing it to meet the diversified refinery needs.[59] It is used mainly for desulfurization of straight-run products but it can be employed also for treating cracked gasolines.[12] The oil vapors may be desulfurized before reforming over bauxite by maintaining a lower temperature level in the treating operation.[65]

Selection between fullers earth and bauxite depends upon the characteristics of charge stocks.[1] Various bauxites differ in their desulfurizing efficiency and some of them are rather inactive.[57] Attempts were made to correlate chemical composition of the different clay catalysts with the desulfurising activity but the available information is inconclusive. Claims were advanced that high lime content insures long life and high catalyst activity while iron sulfide has little effect on catalyst properties[64] although the presence of iron may be conducive to coke formation.[40] The desulfurizing action of catalysts is said to proceed in two directions: decomposition of sulfur compounds with the resulting formation of hydrogen sulfide and breaking up of hydrogen sulfide into hydrogen and sulfur which is absorbed by the clay. Pure calcite, quartz, lime and kaolin are ineffective in promoting the first reaction but brown iron ore appears to be active in this respect.[64, 58] Bauxites of high iron oxide content may favor desulfurization reactions but the oxidation stability of treated oils might be low.[76] The desulfurizing properties of alumina gel are improved by the presence of copper oxide[76] while silica gel was found satisfactory for removing organic sulfides.[88]

The aliphatic sulfur compounds are more easily decomposed than the cyclic compounds[3] although exceptions are not uncommon. For instance thiophene is easily desulfurized by bauxite.[9] Substances like natural gasoline containing almost exclusively the aliphatic sulfur compounds are, therefore, almost completely desulfurized by vapor phase refining[72] and removal of mercaptans does not present any particular difficulty.[9]

Speeding Up Reactions

High temperatures favor desulfurization[10] but cracking reactions are also speeded up. For this reason catalytic cracking is a very effective desulfurizing process and treatment of catalytic gasolines for reducing their sulfur content is seldom required.[40] This is important because the sulfur compounds associated with the cracked gasolines are more refractive and difficult to remove than those found in the straight-run products. It is of interest that at high conversions the sulfur content of gasoline is low and that of cycle stock is high while at low conversions the sulfur content of both products is reduced although the degree of reduction is less for the gasoline.[44] For equal conversions the sulfur content of gasoline is less at the low cracking temperatures.[50] High flow rates through the catalyst bed may be desirable for reducing cracking of hydrocarbons in the catalytic desulfurization processes[48] by establishing favorable time - temperature relationships for the desirable reactions.

Lowering of sulfur content of gasoline with the increase in cracking severity is also observed in thermal cracking although to a much smaller extent than in catalytic cracking. However, the degree of desulfurization varies considerably with the type of crude oil processed.[4]

Various modifications were suggested for refining oils over bauxite and many of them are applicable to other vapor phase desulfurizing agents. Naphtha of poor anti-knock characteristics may be separated into two fractions[64] which are desulfurized under optimum conditions. The lower boiling fraction may be treated at 600-800° F. while the high boiling fraction at 900-1050° F. in order to improve simultaneously its octane rating. The two fractions are then recombined.[50] The lower boiling fraction may also be treated only with a sodium hydroxide solution while the higher boiling fraction desulfurized over bauxite.[46] Claims were made that lead susceptibility of motor fuels may be improved by adding low boiling mercaptans or disulfides to very low sulfur content naphthas before they are passed through bauxite.[42]

Bentonite[74] and charcoal[92] are some of the other materials suggested for vapor phase refining of oils. Dolomite calcined at 1500-1650° F. has been recommended for removing hydrogen sulfide from gasoline vapors before it is oxidized to elemental sulfur.[81]

In the Houdry catalytic treating process[49] the oil vapors are passed through a reactor at 600-800° F. depending on the nature of charge stock and the degree of improvement desired. Pressures up to 50 psi. may be employed. For the reasons already explained no exact demarkation line can be drawn between the desulfurization and cracking conditions, and temperature and pressure may vary even within wider limits than indicated above. Likewise, relatively low temperatures might be used if elimination of unsaturated hydrocarbons and not desulfurization is the primary purpose of refining. Two reactors are employed in parallel in order to alternate between the on-stream and regeneration cycles without interrupting a continuous flow of vapors through the unit. Clay or synthetic catalysts may be used. Catalysts are regenerated by burning the carbonaceous deposits with air. The temperature is regulated by pumping a heat absorbing medium through the tubes located inside the reactors.

In the Perco desulfurization process temperatures of about 750° F. and pressures up to 50 psi. are employed[32, 70] but they may vary within wide limits depending on the nature of the problem. One ton of catalyst, which is bauxite, may treat from 100 to 300 barrels of liquid feed per day. The catalyst is regenerated with air and steam and should be renewed about once a month.

In the Gray desulfurization process, fullers earth is used and the treating temperatures are usually maintained in the neighborhood of 700° F. The oil may first be refined by the Gray treating process employing the same catalysts but lower temperatures in order to eliminate the unstable compounds.

Besides clays and similar adsorbents a large number of substances has been proposed for vapor phase refining of light distillates as shown in Table 1. Only a few of them, however, are, or were in commercial use. Many of these agents were recommended for decolorizing or improving oxidation stability of oils rather than for desulfurization but a change in treating conditions frequently alters their refining characteristics making such differentiation difficult if not impossible. The temperature level at which these substances begin to exhibit desulfurizing properties varies within considerable limits depending on their reactivity towards sulfur. Some of them like metallic sodium,[87] sodium and potassium amalgams[90] or mixtures of molten sodium and parachlorotoluene[69] have a definite desulfurizing action at temperatures well below the vaporization point of the oil while others exhibit these properties only on heating to

TABLE 1

Desulfurizing Agents Suggested for Vapor Phase Refining of Petroleum

DESULFURIZING AGENT	U.S. Patent	Date	Inventor
Alkali hydroxides	480,511-2	8- 9-92	Amend, P. and Macy, J. H.
Alkali metals	1,807,924	6- 2-31	Magill, P. L.
	1,890,881	12-13-32	Magill, P. L.
Alkaline reagents	1,639,513	8-16-27	Phillips, E. B. and Stafford, J. G.
Aluminum chloride	1,872,446	8-16-32	Halloran, R. A., Chappell, M. L. & Oamer, J. H.
Aluminum oxide followed by ferric chloride	1,404,294	1-24-22	Hood, J. J.
Aluminum sulfide	2,015,080	9-24-35	Malisoff, W. M.
Ammonia and molten sodium or calcium	2,002,747	5-28-35	Morrell, J. C.
Ammonia and oxygen in the presence of activated carbon	1,971,172	8-21-34	Benedict, W. L.
Ammonium pentachlorodirinecate and ammonium chloride	2,121,169	6-21-38	Kimball, F. E.
Ammonium persulfate	1,954,488	4-10-34	Morrell, J. C. & Egloff, G.
Berillium and ammonium chloride	1,895,223	1-24-33	Kimball, F. E.
Bog iron ore or fullers earth in colloidal dispersion	1,944,877	1-30-34	Darlington, H. T.
Borax	1,890,229	12- 6-32	Morrell, J. C. & Esery, J. L.
	1,894,096	2- 6-34	Morrell, J. C. & Egloff, G.
Borax and clay	1,890,230	12- 6-32	Morrell, J. C. & Esery, J. L.
Boron phosphate and aluminum oxide	2,441,493	5-11-48	Krug, R. C.
Cadmium sulfide and steel wool	2,080,112	11-10-36	Pierce, R. B. & Trusty, A. W.
Calcium and magnesium chlorides	1,892,801	1- 3-33	Kimball, F. E.
Carbon monoxide	640,918	1- 9-00	Kayser, A.
Chalk	2,248,543	5- 9-44	Johnson, H. R.
Charcoal followed by lime water	563,779	6- 1-97	Whiting, J. R. & Lawrence, W. A.
Chlorides, bromides, sulfates or nitrates of aluminum, cadmium, chromium, cobalt, copper, iron, manganese, nickel or zinc	2,104,791	1-11-38	Craig, W. A.
Chlorine and oxygen followed by zinc oxide	2,306,410	6-25-40	Howard, R. D.
Chromite ore, vanadinite or descloisite	2,016,272	10- 8-35	Buell, A. E. and Schulze, W. A.
Chromium compounds	2,299,496	4-30-46	Matuszak, M. P.
Chromium oxide on alumina gel	2,225,115	7-27-43	Egloff, G.
Chromium oxide on bauxite	2,291,581	7-28-42	Schulze, W. A.
Cobalt chromate and phosphoric acid on fullers earth	1,909,302	8- 7-34	Egloff, G. & Morrell, J. C.
Copper	1,451,052	4-10-23	Rostin H.
Copper, iron or manganese compounds followed by fullers earth	1,840,156	1- 5-32	Gray, T. T.
Copper or iron in hypochlorous, chloric bromic or iodic acid	1,967,172	7-17-34	Morrell, J. C. & Egloff, G.
Copper oxide and sodium hydroxide	1,764,611	1-21-30	Phillips, E. B. & Stafford, J. G.
Copper oxide on fullers earth	1,882,000	10-11-32	Cross, R.
	1,887,113	11-28-33	Gray, T. T.
Copper salt, bentonite and diatomaceous earth	1,887,491	6- 1-26	Cross, R.
Copper turnings, hydrogen chloride and formaldehyde	2,098,089	11- 2-37	Morrell, J. C.
Copper wool	1,804,235	10-26-25	Odom, L. L.
Cresol	2,308,249	1-12-43	Suesselbeck, K.
Cupric chloride	1,733,920	10-29-29	Herthel, E. C.
Cupric chloride and hydrochloric acid	1,988,114	1-15-35	Egloff, G. & Morrell, J. C.
Cupric chloride followed by doctor treatment	955,372	4-19-10	Walker, H. V.
Cupric chloride followed by fullers earth	1,687,992	10-16-28	Phillips, E. B.
Cupric oxide on fullers earth	1,952,751	3-27-34	Gray, T. T.
Cupric oxide suspended in vapors	2,362,296	11- 7-44	Murphree, E. V., Tyson, C. W., Campbell, D. L. & Martin, H. Z.
Cupric oxide with carbonates, hydroxides or oxides of barium, calcium or magnesium and oxygen	2,351,651	10-31-44	Prasil, W. A. & Ovitz F. K.
Cupric sulfate	533,716	7-31-94	Sommer, A.
Cuprous naphthenate	2,423,238	7- 1-47	Hoover, C. O.
Cuprous oxide and chromium oxide on clay	2,372,084	3-20-45	Jones, M. C. H.
Ferric chloride and hydrochloric acid	1,988,083	1-15-35	Morrell, J. C.
Ferric oxide and an alkaline earth metal oxide	738,656	9- 8-03	Burrell, A. W. & Sherman, L. O.
Ferric oxide and hydrated lime	1,712,619	5-14-29	Ihrig, H. K.
Ferric oxide and phosphoric acid	2,105,464	1-18-38	Ault, W. C. & Hochwalt, C. A.
Ferric oxide and steam	1,409,404	3-14-22	Ramage, A. S.
Ferric oxide followed by magnesium oxide	1,404,203	1-24-22	Hood, J. J.
Ferric oxide followed by refining the condensate with charcoal and hydrogen chloride	1,814,410	7-14-31	Richter, A. & Schaefer, W.
Ferric oxide, lime, fullers earth and air	1,973,500	9-11-34	Morrell, J. C.
Ferric oxide, lime, sodium chloride, coke and colemanite	958,820	5-24-10	Parker, J. H.
Granite and steam	372,672	11- 8-87	Hall, T. G.
Gravel	444,833	1-20-91	Hawes, B. N.
Hydrogen chloride and an ore of copper, lead or zinc	1,970,282	8-14-34	Day, R. B.
Hydrogen chloride and a solution of mercuric chloride containing zinc oxychloride	2,083,494	12- 8-36	Egloff, G. & Morrell, J. C.
Hydrogen chloride and a suspension of calcium, chromium, cobalt, iron, lead, magnesium, nickel, potassium, tin or zinc oxide in hydrocarbon oil	2,058,988	10-27-36	Day, R. B.

DESULFURIZING AGENT	U.S. Patent	Date	Inventor
Hydrogen chloride followed by ammonia in the presence of cadmium, copper, lead, mercury or zinc	1,970,281	8-14-34	Day, R. B.
Hydrogen chloride, steam, oxygen and clay	2,087,526	7-20-37	Morrell, J. C. & Egloff, G.
Hypochlorous acid and a salt of copper	1,997,861	4-16-35	Egloff, G. & Morrell, J. C.
Hypochlorous, chloric or iodic acid	2,021,740	11-29-35	Morrell, J. C. & Egloff, G.
Iron oxide	2,126,503	8- 9-38	Retaillian, E. R. P. E. & Wynian, J. B.
Lead	501,988	7-25-93	Carmen, J. F.
	1,474,147	11-13-23	Gray, J. L.
Lead, copper or iron salts of naphthenic or abietic acids	2,397,520	9-30-46	Henderson, L. M. & Schroder, A.
Lead oxide and hydroxides of aluminum and sodium	1,772,985	8-12-30	Culmer, T. W.
Lead oxide or cupric oxide on clay	2,422,982	6- 8-48	Nachod, F. C.
Lime	507,441	10-24-93	Koehler, H.
	2,364,390	12- 5-44	Schaafsma, J. F.
Lithium carbonate	2,186,425	1- 9-40	Moser, F. R.
Magnesium silicate	2,451,564	10-19-48	LaLande, Wm. A., Jr.
Marl	2,348,745	5-16-44	Moriarty, F. C.
Mercuric chloride and hydrogen chloride	2,067,424	10-13-36	Morrell, J. C. & Egloff, G.
Metallic oxides	442,902	12-16-90	Gardner, J. & Harris, J. F.
	543,619	7-30-95	Frasch, H.
	1,205,578	11-21-16	Strache, H. & Porges, P.
	1,349,294	8-10-20	Price, W. B. & Dietz, E.
	1,733,656	10-29-29	Egloff, G. & Morrell, J. C.
Metallic packing	1,541,274	6- 9-25	Perkins, H. F.
Metallic soaps	487,119	11-29-92	Frasch, H.
Metals	379,492	3-13-88	Pitt, W. H.
	622,799	4-11-99	Frasch, H.
	630,496	8- 8-99	Frasch, H.
	1,568,886	1- 5-26	Duckham, A. M. & Morgan, J. S.
	1,609,349	12- 7-26	DuPont, F. I.
	1,685,034	9-18-28	Rider, D.
Minette	1,904,172	4-18-33	Rostin, H.
Nickel	1,828,734	10-27-31	Dorman, J. L.
Nickel, cobalt or iron	2,337,358	12-21-43	Smyrne, A.
Nitric acid	508,479	11-14-93	Kayser, A.
Nitrides at aluminum, barium, calcium, cobalt, copper, iron, magnesium, manganese, nickel or thorium	1,954,843	4-17-34	Schaad, R. D.
Nitrogen dioxide	2,009,996	7-30-35	Morrell, J. C.
Oxidizing agent followed by sodium	2,050,772	8-11-36	Wait, J. F.
Oxygen and steam followed by zinc oxide	2,338,941	1-11-44	Howard, R. D.
Ozone and electric discharge	1,803,964	5- 5-31	Egloff, G.
Ozone, fullers earth and sodium hydroxide	1,957,794	5- 8-34	Morrell, J. C. & Egloff, G.
Permanganates of alkali metals and sodium hydroxide	2,084,197	3-17-36	Morrell, J. C.
Phosphoric acid	2,224,636	12-10-40	Lorena, G. A.
Phosphoric acid and fullers earth	1,946,095	2- 6-34	Morrell, J. C. & Egloff, G.
Phosphorus, acids of	2,192,174	3- 5-40	Ault, W. C. & Hochwalt, C. A.
Potassium hydroxide or carbonate on charcoal and steam	2,379,654	7-13-45	Royer, L. W.
Soda lime on adsorbents	1,904,381	4-18-33	Morrell, J. C.
Sodamide	1,937,914	12- 5-33	Pines, H.
Sodium	1,801,412	4-21-31	Carlisle, P. J.
	1,805,686	5-19-31	Cross, R.
	2,034,068	3-17-36	Wait, J. F.
Sodium and steam	1,902,182	6-12-34	Egloff, G.
Sodium hydroxide	1,728,158	9-10-29	Wheeler, R. C. and Prutaman, P. W.
	1,831,916	11-17-31	Kimball, T. B.
	2,007,146	7- 2-35	Rogers, F. M.
	2,306,843	12-29-42	Reed, W. N.
Sodium hydroxide and hydrated lime	2,034,712	3-24-36	Dolbear, C. E.
Sodium hydroxide and sodium	2,059,542	11- 3-36	Wait, J. F.
Sodium pyrosulfate	1,954,487	4-10-34	Morrell, J. C. & Egloff, G.
Steel wool	1,676,724	7-10-28	Becker, A. E.
Steel wool and solid filtering medium	1,485,093	2-26-24	Kotsebue, M. H. & Bowman, L. M.
Sulfur dioxide and steam in the presence of zinc sulfate	2,040,366	5-12-36	Egloff, G. & Morrell, J. C.
Sulfuric acid	1,411,237	3-28-22	Day, D. T.
	1,464,152-3	8- 7-23	Ellis, C.
	1,681,638	8-21-28	Halle, H. J.
Triethanolamine on adsorbents	1,986,228	1- 1-35	Seguy, J. D.
Vanadium oxide on alumina gel	2,324,067	7-13-43	Connolly, G. C.
Vanadium oxide on silica gel	2,324,068	7-13-43	Connolly, G. C.
Zinc and ammonium chlorides	2,108,438	2-15-38	Kimball, F. E.
	2,171,033	8-29-39	Kimball, F. E.
Zinc chloride	2,291,276	7-28-42	Benedict, W. L.
	2,291,886	8- 4-42	Egloff, G.
Zinc chloride and copper chloride	2,001,185	5-14-35	Day, R. B.
Zinc chloride and hypochlorous acid	2,021,739	11-29-35	Morrell, J. C. & Egloff, G.
Zinc chloride and oxygenated halogen acid	1,957,174	7- 7-34	Morrell, J. C. & Egloff, G.
Zinc chloride and ultraviolet light	1,954,867	4-17-34	Egloff, G.
Zinc chloride containing zinc oxide and hydroxide	2,042,718	6- 2-36	Lachman, A.
Zinc chloride, copper chloride and hydrochloric acid	1,954,486	4-10-34	Morrell, J. C. & Egloff, G.
Zinc chloride or aluminum chloride on adsorbents	2,316,954	4-20-43	Hancock, W. T.
Zinc or aluminum, hydrogen chloride, and formaldehyde or acetaldehyde	1,974,311	9-18-34	Levine, I.
Zinc ore	2,098,943	11-16-37	Buell, A. E. & Schulze, W. A.
Zinc or tin oxide and hydrogen chloride	2,057,530	10-13-36	Morrell, J. C. & Egloff, G.
Zinc or tin oxide, sulfur dioxide and air	1,979,565	11- 6-34	Morrell, J. C. & Egloff, G.
Zinc oxide	2,183,782	12-19-41	Bray, V. R.
Zinc silicate or carbonate	1,970,283	8-14-34	Day, R. B.
Zirconium oxide	2,206,921	7- 9-40	Schulze, W. A.

TABLE 2

Catalysts Suggested for Desulfurizing Oils with Hydrogen

CATALYST	U.S. Patent	Date	Inventor
Aluminum chloride	1,608,328	11-23-23	McAfee, A. M.
Carbonyl chloride and charcoal	1,960,624	5-29-34	Egloff, G.
Clay	820,089	7- 7-06	Day, D. T.
	1,004,632	10- 3-11	Day, D. T.
Cobalt, chromium, copper, iron, manganese, molybdenum, tungsten or zinc sulfides	2,286,347	10-13-42	Corson, B. B. & Monroe, G. S.
Cobalt, nickel or iron molybdate or chromite	2,369,432	2-13-45	Byrns, A. C.
Cobalt molybdate	2,325,034	7-27-43	Byrns, A. C.
	2,417,306	3-11-47	Lee, M. W.
Cobalt thio-molybdate and sodium aluminate	2,037,781	4-21-36	Grosse, A. V.
Cobalt thio-molybdate or thio-tungstate	2,029,100	1-28-36	Grosse, A. V.
Copper, nickel or cobalt	2,073,578	3- 9-37	Gwynn, M. H.
Copper thio-molybdate or molybdate on aluminum	2,325,033	7-27-43	Byrns, A. C.
Iron sulfide	2,143,078	1-10-39	Lyman, A. L., Nichols, H. B. and Mithoff, R. C.
Metal oxides capable of forming sulfides	2,300,877	11- 3-42	Drennan, H. E.
Metal oxide, thiomolybdate and sodium aluminate	2,037,791	4-21-36	Ipatieff, V.
Minette	2,171,009	8-29-39	Rostin, H. & Schuster, K.
Molybdenum or chromium oxides on activated alumina	2,357,365	9- 5-44	VanHorn, L. & Kelly, L. J.
Nickel, cobalt or iron containing more than 0.5% sulfur	2,273,297	2-17-42	Szayna, A.
Nickel or copper on alumina	2,409,690	10-22-46	Nicholson, E. W. S. & Redcay, A. M.
Nickel oxide and sodium aluminate	2,037,789-90	4-21-36	Ipatieff, V.
Nickel oxide, molybdenum oxide and sodium aluminate	2,037,792	4-21-36	Ipatieff, V.
Nickel sulfide	2,298,346	10-13-42	Corson, B. B. & Monroe, G. S.
Platinum or palladium on alumina or silica gel	2,440,673	5- 4-48	Jones, M. C. K.
Sulfide of metal of iron group	2,236,216	3-25-41	Lyman, A., Mithoff, R. C. & Nichols, H. B.
Sulfides of metals immune to sulfur poisoning	1,932,174	10-24-33	Gaus, W. & Pier, M.
Tungsten, cobalt, nickel, molybdenum or iron sulfide, or cobalt molybdate, or molybdenum oxide on alumina, silica, zinc or chromium oxides	2,202,579	1- 8-46	Cole, R. M.
Zinc chloride	2,009,879	7-30-35	Egloff, G.

TABLE 3

Sources of Nascent Hydrogen for Desulfurizing Oils

SOURCE OF HYDROGEN	U.S. Patent	Date	Inventor
Aluminum, berillium, silicon or zinc and an alkali	2,420,218	5- 6-47	Ayers, G. W.
Copper and hydrogen sulfide	1,451,052	4-10-23	Rostin, H.
Magnesium oxide, zinc sulfate or lead carbonate for dehydrogenating the oil and using the released hydrogen for hydrogenating sulfur compounds present in the same oil	2,315,144	3-30-43	Watson, K. M.
Metallic powder and nitric acid	983,354	9-24-01	Thiele, F. C.
Metal releasing hydrogen on reacting with alkalies	1,472,882	11- 6-23	Moody, H. R.
Natural gas	453,578	5-19-91	Mengel, C. C., Sr.
Nickel-aluminum alloy and sodium hydroxide	2,417,041	3-11-47	Ayers, G. W., Barton, D. M. and Harton, E. R.
Nickel or zinc and alcohol	1,428,885	9-12-22	Hayes, A.
Zinc and an alkali	580,652	4-13-97	Schiller, M.
Zinc and glacial acetic acid	1,799,431	4- 7-31	Morrell, J. C

temperatures close to cracking. However, the desulfurizing properties of all reagents improve as the temperature is raised.

Some of the best desulfurizing agents, like metallic sodium, must be applied to the oil with considerable caution because of their excessive reactivity with respect to other than sulfur compounds such as nitrogen bases or certain hydrocarbons. For this reason the choice of the process and of the treating conditions depends to a great extent on the nature of the charge stock. The more saturated is the oil the more drastic may be the refining procedure without seriously affecting the main body of the hydrocarbons.

Inspection of Table 1 shows that chemicals or catalysts suggested for vapor phase refining may be divided into about the same groups as those which were suggested for treating oils in the course of distillation. Many of the chemicals are applicable for both types of processes. Combinations of chemicals may also be employed as well as mixing oil vapors with small quantities of chemically active or catalytic gaseous substances like oxygen, carbon monoxide, chlorine, ammonia or hydrogen chloride. In some of the processes vapors are passed through solid reagents while in others water solutions are employed. The second alternative is used when the boiling point of solutions is comparatively high. The water lost through evaporation is replenished to insure desired concentration of the chemical and to prevent its separation in the solid form.

In the Lachman process the oil vapors are passed through the zinc chloride solution of 70-85-percent strength. The desired concentration is maintained by regulating the quantity of admitted steam. The treating temperature is 300-350° F. and the contact time varies from 2 to 12 seconds. The primary object of refining is improvement in color and oxidation stability of the gasoline. Sulfur removal is negligible and mercaptan content is little affected. However, by employing solid reagent deposited on coke or similar materials and raising the temperature to 680-690° F. mercaptans as well as some of the sulfides and thiophenes are attacked and the product is sweet to the doctor test.[71] In one of the experiments the fresh catalyst contained 75 percent of zinc chloride and 25 percent of zinc hydroxide and other compounds of zinc, oxygen, hydrogen and chlorine. The used catalyst had about 10 percent of zinc sulfide. The desulfurizing activity of zinc hydroxide appeared to be close to that of zinc chloride while the rest of zinc compounds were almost inactive. Phosphoric and sulfuric acids[26] had desulfurizing properties similar to those of zinc chloride while activated carbon was practically inert.

Howard Treating Process

In the Howard treating process oil vapors are mixed with 0.05-0.25 pounds of chlorine per barrel of liquid feed and the mixture contacted with zinc or zinc oxide. The catalyst is regenerated with steam. Removal of hydrogen sulfide and lighter hydrocarbons including butane before treating the oil is desirable.

Hydrogenation is a very effective method for desulfurizing oils. Destructive hydrogenation of crude oil fractions produces gasoline of very low sulfur content. The same is observed in hydroforming. However, removal of sulfur is relatively complete even under mild hydrogenating conditions.[7] This mild hydrogenation may precede destructive hydrogenation[21] of stocks forming very refractive sulfur compounds at high temperatures. Catalysts suggested for the mild desulfurizing operations are shown in Table 2.

Hydrogenating catalysts are often subject to sulfur poisoning. The difficulty was overcome by the development of special types of catalysts of which metallic sulfides are the most prominent ones. By introducing such changes in the catalyst composition effective use was made even of platinum which is normally very easily poisoned. The recently developed commercial reforming process employing a platinum catalyst and known as Platforming is claimed to produce gasoline of 0.002-0.005 percent sulfur content.[58] Observations were made that catalyst poisoning may be prevented or retarded by employing large quan-

tities of hydrogen. For instance nickel hydrogenation catalyst is easily poisoned but will retain its activity if molar concentration of hydrogen and gasoline is maintained at a six to one ratio for oils containing 0.15 percent sulfur or less and a nine to one ratio if the sulfur content is 0.2 percent.[65]

Suggestions were made to improve the oil quality by contacting it with hydrogen prior to distillation[26] or after a preliminary treatment with steam and formaldehyde.[60] The use of nascent hydrogen obtained by the methods shown in Table 3 has been also recommended.

Desulfurization of gasoline with hydrogen may be restricted to the heavy boiling fractions.[17] Extraction of mercaptans may precede the hydrogenation step.[18] Variations in the procedure similar to those described in connection with other vapor phase refining agents may be employed. Strong desulfurizing agents like metallic sodium might be injected into the oil during hydrogenation[47] when handling materials containing very refractive sulfur compounds.

The Cobalt-Molybdate process was recently developed for desulfurizing straight-run and cracked distillates.[15] The oil is treated with hydrogen over cobalt-molybdenum catalysts at 750°F. and 100-250 pounds pressure. Thiophene, thiophane, thioethers and mercaptans are decomposed to hydrogen sulfide and sulfur-free hydrocarbons. The process is claimed to be applicable for treating crude oils containing 5 percent sulfur or more. Such crudes may be desulfurized to yield gasoline of 0.01 percent and heavy distillates in the lubricating oil range of 0.5 percent sulfur content.

Similar processes involving the use of catalysts like tungsten-nickel sulfide,[19] nickel thiomolybdate,[51] or nickel oxide and its mixtures with molybdenum oxide[52] were suggested. The mixture of nickel and molybdenum oxides is claimed to be particularly desirable because of relatively small loss in the octane number of the product after hydrogenation. Desulfurization of catalytically cracked cycle stocks by hydrogenation over different catalysts has been studied.[13]

End of Part VII. Part VIII will appear in an early issue.

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ALUMINUM is of interest to the refining industry as a constructional material. This is because of its resistance to corrosives such as sulfides, organic acids, and furfural. This is also because of its light weight, good heat-transfer characteristics, and low cost. Occasionally additional benefits are obtained which are the result of a lesser tendency to foul up in a specific service.

Inasmuch as aluminum is usually anodic to other common materials of construction, care must be exercised that the equipment is properly designed so as to minimize galvanic attack.

Here are reviewed some actual refinery installations of aluminum in tanks, exchangers, instrument tubing, and insulation weatherproofing. These installations have given both satisfactory and unsatisfactory service. In some cases the installations are recent. The review indicates that aluminum does have a definite place as an economical construction material for refinery equipment.

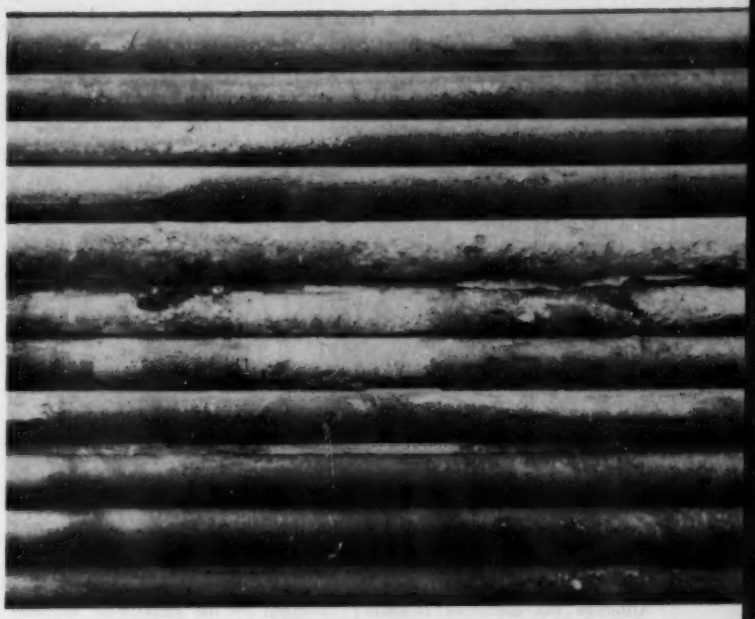

Figure 1. Corrosion of Aluminum Tubes by Copper Salts (Test 7).

Use of Aluminum In Petroleum Refinery Equipment

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ALUMINUM is of considerable interest to the petroleum refiner because of a number of its properties. It is resistant to corrosion by sulfides; and, as every refiner knows, some degree of sulfur corrosion is encountered in most distillation processes. Aluminum is also resistant to corrosion by ammonia, organic acids and furfural. The debit side must also be considered. Aluminum is also resistant to corrosion by ammonia, organic acids, and furfural. The debit side must also be considered. Aluminum is anodic to most of the other common materials of construction or their salts. Hence it is necessary to design installations so that certain ions —such as lead, copper, mercury, and chlorides—are not present, for their presence causes rapid attack of aluminum.

Interest in the suitability of aluminum has been shown in meetings of the Subcommittee on Corrosion of the Committee on Refinery Equipment. It was felt that actual service data would be the most reliable guide for evaluating whether aluminum could be used with economical success in refinery applications. It appeared that sufficient field work has been done that much can be learned from a study of these installations. This paper is an effort to assemble and analyze these

TABLE 1

Nominal Composition and Typical Mechanical Properties of Aluminum Alloys

Alloy and Temper	ALLOYING ELEMENTS						MECHANICAL PROPERTIES		
	Copper	Silicon	Manganese	Magnesium	Zinc	Chromium	Tensile Strength (psi.)	Yield Point (psi.)	Elongation in 2 Inch (Percent)
2S—H14	....	....	....	....	....	....	17,500	16,000	9
3S—H14	....	....	1.2	....	....	....	21,500	19,000	8
4S—O	....	....	1.2	1.0	....	....	26,000	10,000	20
24S—T4	4.5	....	0.6	1.5	....	....	68,000	48,000	19
32S—O	....	....	....	2.5	....	0.25	27,000	12,000	25
61S—T6	0.25	0.6	....	1.0	....	0.25	45,000	40,000	12
63S—T6	....	0.4	....	0.7	....	....	35,000	30,000	12
72S	....	....	....	....	1.0	....	33,000	15,000	17

NOTE: Alclad 3S is a 3S Core with 72S Cladding.

TABLE 2

Aluminum Roofs in Rundown-Tank Service

Test No.	STOCK HANDLED	DISPOSITION			
		Service to 1950 (Years)	Years Before Repairs Were Needed	Years Before Reroofing	Other (Dismantle)
1	Aviation distillate	19	12	..	..
2	Aviation distillate	19	15	..	..
3	Light crude naphtha	..	..	11	..
4	Light crude naphtha	19	14	..	..
5	Light naphtha	..	..	14	..
6	Light naphtha	18	13	..	..
7	Light naphtha	19	14	..	..
8	Light naphtha	17	13	..	..
9	Light naphtha	19	..	..	..
10	Light naphtha (sweet crude)	19	..	..	..
11	Light naphtha (rerun)	19	..	..	..
12	Light naphtha	18	..	..	..
13	Heavy naphtha (sweet crude)	..	..	14	..
14	Heavy naphtha (sweet crude)	17	10	..	..
15	Heavy naphtha	18	..	..	..
16	Kerosine	19	10	..	..
17	Kerosine	19	11	..	..
18	Kerosine	19	10	..	..
19	Kerosine	18	11	..	..
20	Kerosine	17	11	..	..
21	Kerosine	16	..	..	..
22	Kerosine	..	..	..	14
23	Kerosine	..	..	..	14
24	Kerosine	..	..	..	14
25	Kerosine	..	..	..	14
26	Light cracking stock	14	4	..	..
27	Gas oil	..	..	..	19

data. To this end, the members of the corrosion subcommittee were asked to submit the information available.

Although the corrosion resistance of aluminum is of most interest here, the other properties should not be completely ignored. Aluminum is, of course, light in weight. This is perhaps best illustrated by considering that a tube bundle with a diameter of 16 feet 36 inches weighs about 12,000 pounds if constructed of a steel skeleton and brass tubes. In aluminum, this same tube bundle would weigh about 4000 pounds. The greater ease of handling is apparent.

Aluminum also has excellent heat-transfer characteristics. Undoubtedly this fact is associated with corrosion characteristics, as will be shown later. Other physical and mechanical properties are discussed, together with their effect on equipment design by Plummer,[1] and need not be repeated here. For convenience, Table 1 sets forth the chemical composition and typical mechanical properties.

Storage Tanks

Probably the most notable installation of storage-tank roofs has been made by Humble Oil & Refining Company. The details of construction and comparisons with other methods of construction have been published previously by Camp[2] and Plummer.[1] Table 2 shows the experience to 1950 of these roofs, which are in run-down-tank service. The one point which should be repeated here is that the possibility of galvanic corrosion must be considered during the design stage.

It will be seen that 19 of the 27 roofs are still in service. Of these 27 roofs, 21 have required repairs and protection at points where aluminum contacts steel. Such protection has been attained by the installation of reinforced gunite at these points. Three roofs were renewed with gunited steel roofs because they had been subjected to severe galvanic attack. Five other roofs were retired from service.

It will be seen that resistance of aluminum roofs to general corrosion has been satisfactory.

Tank Accessories

We have had satisfactory results in most cases with vent valves and flame arresters of aluminum construction. This experience is confirmed by Harnsberger,[7] although he mentions that a phenolic resin material is being substituted to a large degree for aluminum parts in vent valves.

Vessel Internals

Aluminum pressure vessels apparently have not been used to any great extent. We are currently testing aluminum bubble caps in crude distillation, thermal cracking, and furfural refining processes. We do not have sufficient data to evaluate the usefulness of aluminum in these services.

Exchangers

The primary interest at the present time seems to be in the evaluation of aluminum for heat-exchanger equipment. The data have been tabulated in Table 3.

A) Crude and Thermal Cracking Service

Test No. 1: This was a vapor heat exchanger associated with a lubricating-oil-crude-topping unit. As noted, both steel and copper-alloy tubes are subject to rather severe sulfide corrosion. Preliminary tests indicated the suitability of aluminum 61ST alloy, and a trial bundle was installed. Failure occurred in one month's time; this failure took the form of severe pitting from the vapor side. Damage was so extensive that repairs were not possible. The vapor is largely gasoline, with hydrogen sulfide and water present in appreciable quantities. The pH of the vapor is controlled to approximately 7 by ammonia injection into the vapor line. The attack was more intense near the outlet and in dead areas near the baffles.

The tubes were carefully examined in the laboratory, where spectrographic analysis revealed minute quantities of mercury in the corrosion pits. It is probable that the very active aluminum-mercury cell was responsible for the attack. The source of the mercury is not known, although it is known that California crudes often contain traces. It is also known that traces of mercury can cause severe attack of aluminum.

Test No. 2: This concerns a small experimental 6-inch pipe exchanger, where a 3S and two Alclad 3S tubes were installed. The exchanger is in parallel with the top condensers on a topping unit which handles sour vapors into which water vapor and ammonia have been injected. The experience was very similar to test No. 1, in that 16-gauge tubes were completely pitted through in 2 months' time.

Test No. 3: This is a conventional shell-and-tube exchanger, located in a lubricating-oil distillate rerun unit.

It will be noted that some corrosion occurred where aluminum tubes contacted steel baffles. This took the form of pitting to a depth of 0.006 inch. It is believed that this attack occurred during the shutdown periods, at which time the exchanger shell would have been steamed out. No galvanic attack was noted on the water side where aluminum tubes contact aluminum tube sheets. Although the cladding is corroding away, there seems to be enough remaining to protect the base metal.

The admiralty and red-brass tubes in this service, which lasted 34 months and 48 months respectively, failed because of pitting of tubes on the water side. No failures of aluminum have been experienced to date. Aluminum was selected in this case as a trial bundle to determine the resistance of Alclad 3S to salt-water corrosion. No other preliminary test data are given, and this test is continuing.

Test No. 4: This case concerns a small all-aluminum exchanger which

TABLE 3

Service Data of Aluminum Tube Bundles

STREAM	SHELL SIDE: Temp. In °F.	Temp. Out °F.	Pressure (psi.)	Tube Sheets Material	Baffle Material	Shell Material	Stream	TUBE SIDE: Temp. In °F.	Temp. Out °F.	Pressure (psi.)	Tube Material	Protection Measures	Time on Test (Mos.)	Test Results	OTHER MATERIALS USED: Material	Life (Mos.)	Type of Corrosion	References
Crude-tower OH vapors	....	....	....	....	....	....	.....	....	....	....	....	.....	1	Complete failure by pitting from vapor side; traces of mercury found in pits believed responsible; mercury may come from California crude oils.	Steel: admiralty	12 30	Severe sulfide attack.	3
Crude-tower OH vapors	....	....	....	....	....	....	.....	....	....	....	....	.....	2	Perforated; similar to foregoing bundle	.....	.....	.....	3
Lube distillate, non-corrosive	400	170	120	Alclad 48	Steel	Steel	Water: 1,500 to 20,000 ppm NaCl	76	108	....	Alclad 38-H14	.....	18	Most of cladding gone inside of tubes; minor corrosion where tubes contact baffles; i.e., pits, 5 mils; could have been caused by steaming out for shutdown.	Admiralty and Munts Red brass T8 and Munta T8	34 48	..... . Pitting from water side.	.. 10
Thermally cracked gasoline	410	....	....	Alclad 38	....	38-H14	Water: pH, 6 to 7	....	....	....	Alclad 38	....	13	Small hole corroded through ⅛-inch-thick shell; no analysis of cause.	.....	..	.....	
Catalytically cracked gasoline	200	156	8	Alclad 38	....	38-H14	Water-cooling tower; pH, 7.	76	78	40	Alclad 38	All aluminum	4	Shell side: discoloration of tubes caused by carry-over; no measurable attack. Tube side; pitting of tube sheets and tubes; perforated cladding in small areas.	Admiralty	14	Severe scaling and plugging of bundles.	Sohio
Catalytically cracked gasoline	200	156	8	Alclad 248	618-T6	Steel	Water-cooling tower: pH, 7.	80	120	40	Alclad 38	.....	4	Not inspected to date, but no trouble reported; bundle idle for additional two months.	.....	..	.....	Sohio
Catalytically cracked gasoline vapors	200	122	8	Steel 304; stainless, clad on water side	Steel	Steel	Cooling-tower water	90	120	40	Alclad 38, ¾-in.-o.d., BWG*	None	6	Tube corroded through where contacted by scale from admiralty tie-rod spacers; corrosion at baffles; tube ends corroded on water side.	Admiralty Type 316, stainless	14 24	Thick sulfide scale plugs bundles. No failures to date.	Sohio ..
Synthetic-tower OH	250	....	....	Alclad 48	38-H18	38-H14	Water: pH, 6.8	....	....	....	Alclad 38	All Aluminum	9	Satisfactory condition; still in service	.....	..	.....	4
Fluid-fractionator OH: 1 percent H_2S, 1.08 percent NH_3	167	111	45	....	....	....	Water: Delaware River, one-shot chlorinated	68	108	1.6 in. to 18 in. of mercury (vacuum)	Alclad	Asbestos gaskets	12	Moderately dirty on tube side; no failures to date.	Red brass	4	Ammonia attack	5
Catalytic-cracker OH condenser	....	....	....	Steel	Steel	....	Water	....	....	....	Alclad 38	.....	15	80 percent of internal cladding gone, and some penetration of base metal; little external corrosion; steel bundles installed at same time in same condition as aluminum.	Admiralty	36 to 48	.....	3
OH from H_2S-NH_3 stripper tower: 7.75 percent H_2S, 7.0 percent NH_3	240	165	15	....	....	....	Water: Delaware River, chlorinated	68	....	5	Alclad 38	Asbestos gaskets	3½	Not inspected to date, but no failures to date.	Steel	½ to 1½	.....	5
Crude-still wet gas: 100 grains S per 100 cubic feet	174	141	88	Alclad 48	38-H18	38-H14	Water: pH, 7.4	63	76	60	Alclad 38	All aluminum	10	Shell: no visible corrosion. Tubes: white deposits. Some pitting of tube sheet, approximately ⅛ inch deep when asbestos gaskets came in contact with aluminum.	Admiralty	12 to 20	Corrosion from wet gas.	Sohio
Stream	210 to 298	....	0 to 50	618-T6	38-H18	Steel	Sour light (32-deg.-API-gravity) heating oil, West Texas crude	125	180	65	38-H14	Asbestos gaskets	11	Glass from broken sample bottle cut gash 1 in. in length in tube after 6 months' service; no no other trouble; no corrosion or fouling.	Steel	120	Rusting and pitting	6
15 percent ammonia solution and vapor	90 to 100	65 to 75	0 to 2 in. of mercury (vacuum)	Steel	Steel	Steel	Water	60 to 70	75 to 85	40	Aluminum	None	½	Complete failure of tubes.	Steel	30 to 36	Pitting on water side	5
Raffinate	380	....	....	248-T4	....	....	85 percent oil, 15 percent furfural	306	....	....	618-T6	.....	7	No corrosion reported; cleaning frequency reduced.	.....	..	.....	3
Raffinate	330	....	....	248-T4	....	....	85 percent oil, 15 percent furfural	265	....	....	618-T6	.....	14	No corrosion reported; cleaning frequency reduced.	.....	..	.....	3
Furfural and water	....	....	....	618-T6	....	....	Water	228	....	....	Alclad 38	.....	14	No corrosion reported; cleaning frequency reduced.	.....	..	.....	3
Dry furfural	418	....	....	248-T4	....	....	17 percent oil, 3 percent water, 80 percent furfural	315	....	....	618-T6	.....	22	No corrosion reported; cleaning frequency reduced.	.....	..	.....	3
Dry furfural	335	....	....	248-T4	....	....	17 percent oil, 3 percent water, 80 percent furfural	270	....	....	618-T6	.....	37	No corrosion reported; cleaning frequency reduced.	.....	..	.....	3

* Birmingham wire gage.

takes thermally cracked gasoline vapors. No cause is yet known for the corrosion of a small hole through the shell in 13 months.

B) Catalytic Cracking Service

Tests No. 5, 6, and 7: These constitute a series of tests being carried out in one of our refineries. Test No. 5 was an experimental all-aluminum exchanger supplied by Aluminum Company of America. After a successful four-month test, the refinery retubed an existing skeleton with Alclad 3S tubes; two all-aluminum bundles were also purchased for trial (test No. 6).

The corrosion conditions are rather complex. It has been found that the operation of this fixed-bed catalytic cracker causes a constant cycling of pH of the condensate. The range in pH varies from about 6 to 8.5, and this swing would be greater if it were not for recycling the condensate water back into the vapor line and injecting ammonia during the acid portion of the cycle.

The all-aluminum bundles have been in service for four months, and no trouble has been reported to date. The retubed bundle (test No. 7) was found to be leaking after 6 months' service. Severe corrosion was found with gaping holes, about one inch long, which had been opened in the tubes adjacent to admiralty tie-rod spacers which had been used. The corrosion products which are largely copper and zinc sulfides, were in contact with the tubes adjacent to the spacers. This condition is shown in Figure 1. Holes were opened up where tubes had passed through the steel baffles. These are thought to have resulted in part from accumulation of copper corrosion products, as there was little evidence of galvanic action at the juncture of the tubes and tube sheets. This condition is shown in Figure 2.

On the water side it was also noted that the tube ends were corroded, where they were adjacent to type 304 stainless cladding. The tubes most affected were in the topmost row, and the others were less affected. It is thought that zinc strips would protect the topmost tube ends.

Test No. 8: This is another case of a test exchanger which is installed in the overhead condensing service of a catalytic cracker. This test is apparently successful after nine months.

Test No. 9: This is an aluminum bundle which condenses catalytic gasoline from a fluid unit. The feed stocks for this unit are derived from Poza Rican, Mid Continent, Santa Barbara, and Abqaiq crudes. The bundle is isolated from the steel shell by asbestos gaskets. To date the tube bundle has been in service for 12 months, and has been found to be moderately dirty on the tube side. No corrosion was reported. Previous red-brass tubes failed after four months' service because of ammonia attack. The saving in costs with the use of aluminum tubes appears to be appreciable.

Test No. 10: This is an overhead condenser on a cat-cracker. It consists of Alclad 3S tubes in steel tube sheets and baffles. Although there was doubt as to the advisability of using this galvanic combination because of the water involved, the project proceeded. When the first inspection was made six months after installation, there was no external corrosion, and the internal corrosion was very slight. The next inspection after 15 months found about 50 percent of the internal coating gone and some penetration of the tube wall. No leaks have developed since the last inspection. It is anticipated that the service life will be greater than with admiralty.

At the same time the aluminum bundles were installed, two steel bundles were also put in service. The service to date is comparable to aluminum; 16-gauge aluminum tubes cost about 1¼ times as much as 14-gauge steel tubes.

Test No. 11: This was a condenser on the overhead from a hydrogen-sulfide-ammonia stripper tower in a fluid catalytic cracker. The corrosive agents were ammonium sulfide and polysulfides from the stream, which contained 7.75 percent hydrogen sulfide and 7.0 percent ammonia. The present exchanger has given two to seven times the service previously obtained from steel.

C) Other Applications

Test No. 12: This test was started because admiralty tubes were so badly corroded that replacement was required about once per year. As shown, the test has been successful over a ten-month period. Because of a change in corrosive conditions, however, admiralty tubes have lasted 30 months. Water corrosion indicates the need for clad tubes and tube sheets, and appears to be the limiting factor. The water analysis follows:

Phenolphthalein alkalinity....
0 ppm. of calcium carbonate
Methyl-orange alkalinity....
191 ppm. of calcium carbonate
Chlorides 87 ppm. of sodium chloride
Sulfates..165 ppm. of sodium sulfate
Hardness....
297 ppm. of calcium carbonate
pH..... 7.4

An analysis of the corrosion deposits on the water side gave the following data:

Major constituents (>1 percent)
Iron
Magnesium
Aluminum
Silicon
Calcium
Minor constituents (0.0 to 1.0 percent)
Copper
Trace elements (<0.1 percent)
Lead
Tin

Test No. 13: In this shell-and-tube exchanger, all-aluminum construction was used for the tube bundle. The remainder of the exchanger parts are of welded carbon steel. At joints between the carbon steel and aluminum, such as between the channel and the tube sheet, compressed asbestos gaskets are used. Steel bolts are used at all joints.

After six months of service a leak occurred in the bundle, and it was removed for examination. It was found that a piece of glass had entered the tube and cut a gash about 1 inch long through the tube wall—causing leakage. It was concluded that the glass from a broken sample bottle had probably entered the bundle with the oil stream from the tankage. No corrosion or fouling on any aluminum surface was in evidence. The bundle was returned to service, and a strainer was installed upstream to prevent a recurrence of mechanical damage. Since this occurrence, the bundle has been trouble-free, and has been in service for a total of 11 months.

As shown, the aluminum tubes replaced steel tube bundles which were good for about ten years' service. The outside of the steel tubes was subject to considerable rusting and scale formation by the steam. This reduced considerably the efficiency of the bundle, and necessitated frequent cleaning. In addition, pits formed under the corrosion products, and necessitated the retirement of the tubes.

This tube bundle was installed as a full-scale field test. It serves better

TABLE 4

Service Data of Aluminum Heat-Exchanger Bundles in Furfural Plant

Test No.	Tube Side	Shell Side	Area (Square Feet)	BRASS BUNDLE		ALUMINUM BUNDLE		Estimated Savings (Dollars Per Year)
				Inside	Outside	Inside	Outside	
17	Water, 225° F.	Furfural, water	34	12	12	--	--	....
15	85 percent oil, 15 percent furfural, 305° F.	Raffinate, 380° F.	325	1½	4	6	18	1,000
16	85 percent oil, 15 percent furfural, 265° F.	Raffinate, 320° F.	325	1½	4	6	18	800
19	17 percent oil, 3 percent water, 80 percent furfural, 270° F.	Dry furfural, 325° F.	370	4	4	24	36	300
18	17 percent oil, 3 percent water, 80 percent furfural.	Dry furfural, 418° F.	1,600	4	4	18	18	1,000

than the two carbon-steel bundles previously used, and as yet has required no maintenance because of corrosion or fouling. It has been estimated that the new aluminum bundle is operating at twice the heat-transfer efficiency of the two previously used steel bundles. At the time replacement of the steel bundles was being considered, the use of admiralty was considered because of its anti-fouling and better heat-transfer characteristics. An investigation revealed that a bundle of aluminum would be less costly, and that better heat-transfer and fouling factors would be obtained. The cost comparison between aluminum and admiralty showed a distinct economic advantage for aluminum.

Test No. 14: This was an ammonia absorber of fixed tube-sheet design. It was constructed of welded carbon steel throughout except for the aluminum tubes. The failure in six days is attributed to ammonia corrosion.

D) Furfural Refining

Tests No. 15, 16, 17, 18, and 19: This section concerns the use of aluminum in furfural service. Here the problem was not primarily corrosion, but its after-effects. A great deal of trouble was encountered with the rapid formation of heavy, tightly adherent furfural resin on all copper-alloy tubes. The high incidence of resin formation caused severe fouling and plugging of tubes. Therefore, frequent cleaning was essential to prevent warping or complete loss of the bundles. At best, the cleaning jobs were poor because of the extreme tenacity and insolubility of the deposit.

Analysis of the troublesome deposits always indicated traces of copper. Laboratory investigation further confirmed that furfural which contained traces of copper soaps polymerized at lower temperatures and at faster rates than furfural to which no copper soaps had been added. It was, therefore, suspected that the copper at the tube surface was acting as a specific promoter for the polymerization of furfural.

To test the suitability of aluminum in furfural service, two new aluminum-alloy tubes were installed adjacent to three new inhibited admiralty tubes in a vapor heat exchanger. This unit was used to condense furfural vapors at approximately 420° F. After 2½ years of intermittent service, the aluminum tubes had remained clean, whereas the admiralty tubes had fouled heavily. Five tube bundles have since been used in this type of service. By using skeletons and tubes of 61ST and tube sheets of 24ST, rolling characteristics close to those of copper-alloy tubes were attained. To date no trouble has been experienced with leaking rolls.

Figure 2. Corrosion of Aluminum Tubes at Steel Baffles (Test 7).

Table 4 shows the outstanding success of aluminum in furfural service. It will be noted that substitution of aluminum for brass in the five furfural plant bundles has resulted in an aggregate saving of approximately $3000 per year in cleaning costs alone. In addition, downtime has been reduced, and higher average heat-tranfer coefficients prevail. Furthermore, no corrosion attack has been observed, and unlimited life is anticipated for these bundles.

It is understood that other refineries have solved this problem of resin formation by the use of stainless-steel elements. Because of the low conductivity and high material cost of stainless steel, it is probable that the initial cost of stainless-steel units was 7 to 10 times that of aluminum.

Figure 3 shows a comparison of costs for all aluminum tube bundles, and bundles with brass tubes and steel skeletons. It will be seen that the brass and steel bundles are considerably more expensive.

It is believed that the record of tests bears out the unsuitability of aluminum in contact with heavy metals. One other aspect is the effect of temperature. Holmberg[6] has commented that aluminum was used in exchangers and other equipment in some gasoline plants in West Texas ten years or more ago. The aluminum was corrosion-resistant, but so was steel. When the aluminum exchangers were removed from service, creep failures were imminent. Because of the low strength at higher temperatures, aluminum was not so satisfactory as steel.

In the other heat-exchange services shown, it appears that aluminum will be economical tube material. It is understood that aluminum has also been used for other types of service, and it is to be hoped that information concerning these applications will be forthcoming.

Instrument-Air Tubing

In our company tests were started on aluminum instrument tubing because of the economic advantage. Copper tubing may cost 60 percent more than aluminum tubing. The cost of aluminum fittings is about the same as brass, and we believe aluminum fittings will be cheaper in the future.

The corrosion conditions are determined essentialy by the atmosphere in which the installation is made. Ordinarily, in our Sohio refineries, the instrument air is dehydrated before it is put into the system. Consequently, no corrosion is expected internally. The one other circumstance which is likely to lead to corrosion is the so-called poultice action, which is likely to occur where tubing is put into racks and where wood spacers are used to separate the various tubes. Care must be taken that there are no

TABLE 5
Tests of Aluminum Instrument Tubing

Test No.	Location	Type	Test Time (Months)	Results	Reference
1	Ultrawet plant	4S0	9	Complete disintegration because of hydrogen chloride and aluminum chloride	9
2	Samples distributed throughout refinery	4S0 tube brass connectors	24	White oxidized coating; some evidence of pitting; slight galvanic attack at connectors	9
3	Still areas where hydrogen sulfide is high		21	Very good; little indication of corrosion	10
4	Gas plant	4S0 tube aluminum connectors	18	Very good; little indication of corrosion.	Sohio
5	Catalytic gas plant	Brass connectors.	37	Very dirty; little evidence of galvanic corrosion.	Sohio

points where moisture can collect and remain against the aluminum tubing.

The available test data are given in Table 5.

As a result of test, Lepley[9] reports that his company expects to use aluminum except where there is concentration of acid fumes or in important refining units where the possible failure of instrument lines might result in serious upset to operation. This is subject to future revision.

We are also using aluminum in part of our newer units. Test No. 4 includes the installation of approximately 6500 feet of tubing. Type 4S0 tubing was specified, because it has somewhat higher fatigue strength than other tubing alloys. This may be important when it is used around pumps or under other vibrating conditions.

Our test No. 5, which has been in for the longest time, is a section of tubing with brass fittings, placed in a painted angle-iron trough for support. As noted, there is little evidence of galvanic corrosion to date, even though the atmospheric conditions are severely corrosive.

Insulation—Weatherproofing

Aluminum has been used for the weatherproof jacketing on insulation by many refiners. For the most part such installations have been satisfactory. However, in those cases in which asbestos-cement or 85-percent-magnesia insulation has had an opportunity to become damp, rapid corrosion of aluminum can be expected. This is because portions of the cement or magnesia are soluble in water and are alkaline.

The use of aluminum offers an economic advantage, because 28-gage sheet metal in galvanized iron costs 6.6 to 7.0 cents per square foot, whereas aluminum of the same gage costs 5.3 to 6.2 cents per square foot.

In some of our operating units corrosion of galvanized iron is very severe. Part of this can be blamed on the quality of the galvanized sheeting; part of it can be blamed on the hydrogen sulfide from the unit; and part on the severe industrial atmosphere. Galvanized iron shows rust streaks in two to three years.

In order to determine the suitability or advantage of aluminum, 27-gage aluminum sheeting was installed over existing insulation in the locations shown in Table 6. It will be seen that the aluminum was excellent in most cases. Test No. 7 was near a flapper vent on a drum which contained heat-transfer salt. Apparently there was enough carry-over of salt to cause the aluminum to be perforated in nine months' time. Tests No. 5 and No. 6 were placed on a superheated steam line which was used intermittently. This was the most severe test we could find, inasmuch as there was water splashing constantly on the outside of the line. The insulation was wet. When the aluminum sheet was removed, pieces of cloth which covered the insulation still adhered to the aluminum. This cloth had almost disintegrated. On the 3S sheets, pits were found at random where the aluminum had contacted the insulation. These pits averaged about 10 mils deep, and one perforation of the 16-mil-thick aluminum was found. The Alclad 3S aluminum contained pits approximately 6 mils deep, and no perforations were found. Some advantage, therefore, is seen for the use of an Alclad material, although it is felt that even this would be perforated in time.

There are some companies which supply aluminum which is corrugated, and which has a moisture barrier between the insulation and the aluminum. This type of material should satisfactorily overcome the problem of wet insulation. We have found, however, that the aluminum used is thin, and that it is soon perforated if walked on or struck with a sharp object. We also find that this type of installation is more expensive than the use of a heavier aluminum sheet.

From the results of our tests, we believe that aluminum is satisfactory as insulation weatherproofing in most instances. It is not satisfactory, however, when used over wet magnesia insulation. Our tests are fairly well corroborated by the results of others. Harnsberger[7] has indicated that his company's experience with aluminum has not been satisfactory because of contact with asbestos cements. For that reason the company has discontinued using aluminum, and it is using galvanized sheets. This was its original specification, and it only used aluminum as a substitute during the war period when galvanized material was impossible to obtain.

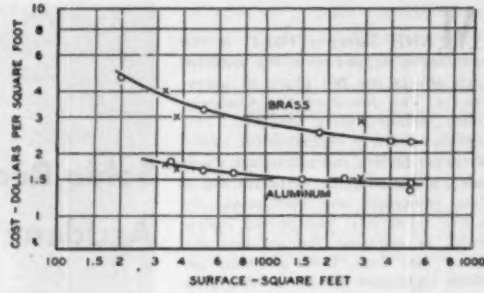
Hafsten[11] has indicated that aluminum has been used in place of sheet steel for insulated tanks and lines, and has been generally satisfactory. One

TABLE 6
Tests of Aluminum Insulation Weatherproofing

Test No.	Alloy	Band Alloy	Type of Insulation	Location	Test Time (Months)	Results
1	2S	Steel	Air cell	Cylinder stock to storage	26	Satisfactory condition inside and out; light rusting beneath steel band.
2	2S	Steel		140-lb. steam line	26	Satisfactory condition inside and out.
3	3S	52S0	Magnesia	140-lb. steam line	35	Rough outside; bright inside except ends, where tied into existing galvanized iron.
4	Alclad 3S	52S0	Magnesia	140-lb. steam line	35	Rough outside; smooth inside except ends, where tied into existing galvanized iron.
5	3S	52S0	Magnesia	Superheated steam line	35	Very rough outside; insulation wet; caused random pits about 10 mils deep; one perforation.
6	Alclad 3S	52S0	Magnesia	Superheated steam line	35	Rough outside; insulation wet; and canvas disintegrating random pits 6 mils deep.
7	Alclad 3S	52S0	Unibestos	Vent from salt drum	9	Corroded through because of carry-over of heat-transfer salt.
8	Alclad 3S	52S0	Unibestos	20-lb. exhaust steam line	35	Dirty; O.K.
9	Alclad 3S	52S0	Unibestos	140-lb. steam header	35	Dirty and discolored; no loss of thickness; corroded internally where it contacted galvanized wires.
10	3S	52S0	Unibestos	20-lb. exhaust-steam line	35	Dirty and discolored; no loss of thickness; corroded internally where it contacted galvanized wires.
11	3S	52S0	Unibestos	Evacuation line	35	Dirty and discolored; no loss of thickness; corroded internally where it contacted galvanized wires.
12	3S	52S0	Magnesia	Coil outlet line	35	No internal corrosion.
13	Alclad 3S	52S0	Magnesia	Coil outlet line	35	No internal corrosion.
14	Alclad 3S	Steel	Magnesia	Gas to drum	35	Slight grooves at bands.
15	2S-corrugated	52S0	Magnesia	140-lb. steam line	20	Pierced by sharp objects soon after installation because it was only 0.005 inch thick; moisture barrier protects aluminum.

failure was reported when aluminum was applied over magnesia insulation on a pipe line.

FIGURE 3



Piping

Northup[6] has reported a test installation of 5 miles of 4-inch and 6-inch aluminum pipe of all-welded construction (Heliarc process), except where joined to existing steel pipe. At these points aluminum flanges are used. The materials' specifications are as follows:

4-inch—63S-T6—0.220- to 0.247-inch wall pipe.
6-inch—63S-T6—0.253- to 0.280-inch wall pipe.
4-inch—63S-T6—series 60 flanges.
6-inch—61S-T6—series 60 flanges.
24S—anodized flange bolts.
43S—welding wire.

Flanges were installed with bakelite sleeves, gaskets, and washers. The line was exposed to the following corrosive agents:

1) Iron sulfide and scale from corroding steel pipe in the same system.
2) Approximately 7 cubic feet of hydrogen sulfide per 100 barrels of oil.
3) Brine.
4) External marshy soil conditions.

This pipe was installed early in 1948. In the fall of 1949 an inspection indicated that external corrosion had occurred on one section of 4-inch pipe in a marshy area of southern Arkansas. An analysis indicated that this corrosion had resulted from poultice action of adherent heavy clay, chlorides, and heavy metals in acidic water. Pitting had occurred to a maximum depth of $\frac{1}{32}$ inch.

Internal pits were also in evidence, and the internal corrosion rate was estimated to be about $\frac{1}{8}$ inch per year. At this rate leaks were predicted for 1950.

The aluminum pipe did fail in April, 1950, after 26 months' service. The first leak was caused by internal pitting in the 4-inch section of pipe. The pit which caused failure, as well as all of the deepest pits found, was located in a 1-inch-wide band on each side of the weld. This band probably was annealed by the heat of welding. The majority of pits were on the bottom third of the pipe. The failure resulted in a complete inspection of the line, and all the aluminum pipe was found to be corroded internally.

The replacement material has not been selected, but a test of other aluminum alloys is to be initiated. It is expected that this test will consist of 10-foot sections of four different aluminum alloys which will be installed at various corrosive locations.

Steel pipe has been, and still is, used for this service. The steel is subject to severe corrosion from sour crude, and in a few years is beyond economic use. The steel also is corroded from brine, scale, and hydrogen sulfide which are allowed to settle during slack periods. The bottom one-third of the pipe is affected most.

Pump and Turbine Packing

Northup[6] has reported two cases of packing for blowers and turbines. The first was a labyrinth-type packing and inter-stage seal rings used on a steam turbine. The steam was superheated, and it entered at a pressure of 650 psi. at 700° F. The aluminum, a casting, had the following nominal composition, as given by the manufacturer:

Element	Percent
Tin	7.0 to 9.0
Copper	4.5 to 5.0
Nickel	0.8 to 1.2
Manganese	0.4 to 0.6
Silicon	0.5
Iron	0.5
Aluminum	remainder

The aluminum parts failed after about three months' operation. Failure was attributed to high-temperature steam (600° F.) at the first stage. The steam apparently reacted directly with the aluminum to form aluminum oxide and hydrogen. The attack was probably initiated by hot deaerated condensate and/or alkaline carry-over from the boilers. These were of sufficient intensity (pH, 10.0) to corrode the protective oxide film normally present on the metal surface. There was no evidence of defective materials, and no galvanic corrosion is reported—although the aluminum was in contact with cast-iron and cast-steel case parts and a forged-steel shaft.

Bronze replacement parts were used, and these have been satisfactory after one year's service—although no inspection has been made.

The second case is a centrifugal blower which takes air at —30° to + 100° F., and discharges at a pressure of 15 to 30 psi. at a temperature from 250 to 300° F. No filters are used. Again aluminum was used as a labyrinth packing and as inter-stage seal rings. The aluminum composition is the same as that previously given for the turbine.

This blower has been in service for eight to nine years, and no corrosion has been experienced, even though the aluminum is in contact with the cast-iron casing and alloy-steel shaft. The aluminum parts are expected to last about 20 years without replacement.

In both cases aluminum was selected in order to obtain the following properties:

1) A soft material which would not score the shaft.
2) An easily machined material so as to obtain the necessary close tolerances.
3) An easily cast material to reduce cost.
4) A corrosion-resistant material so as to prevent by-passing.

Summary

It is believed that the recital of the tests already carried out by petroleum refiners indicates the suitability of aluminum for various types of service. In many cases aluminum is much less expensive than other materials of construction. Considerable care must be exercised in evaluating the corrosive nature of the environment if aluminum is to be used. Care must be exercised in the design stage in order to reduce or prevent galvanic attack between aluminum and other materials of construction.

The contributions of the various members of the corrosion subcommittee should be acknowledged, inasmuch as their test results are being presented here. We should also like to acknowledge the help of Aluminum Company of America, which supplied much of the material used in our own tests.

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Sohio Reduces Its Refinery Accident Ratio 65 Percent

"MAKE Safety a Habit" is the slogan for a stepped-up safety program which affects the full phase of operations of The Standard Oil Company (Ohio) manufacturing division. This program of safety education for supervisory, production and maintenance personnel, along with the extensive use of safety equipment and instruments (in all five refineries), has proved instrumental in reducing the accident frequency rate from 12.87 accidents per million manhours to 4.60 in 1950, a reduction of more than 65 percent.

When E. B. McConnell was appointed vice president in charge of manufacturing several years ago, he outlined a program to make every employe's job safer by teaching safe work methods and by eliminating physical hazards. To this end employes are schooled in safe practices, in the use of various types of personal protective equipment required for the hazards of their work, and in correcting and reporting unsafe conditions.

Every man from the safety engineer on down the line is made safety conscious through discussions, meetings, bulletin board releases, personal contacts, payroll enclosures and safety grams.

In addition to promotional and educational efforts, Sohio has recognized a need for personal protective clothing and equipment as part of the complete accident prevention program. Each of the five refineries, located in Cleveland, Toledo, and Lima, Ohio, and Covington, Ky., is supplied with a full complement of gas masks, hose masks, respirators, goggles, safety hats, combustible and toxic gas detectors and other necessary items of personal protection.

All refinery employes working where falling objects are a continuing hazard, are required to wear safety hats, usually aluminum alloy headgear. Incidents where men are saved from serious injury or possibly death, are given full publicity treatment in the department's own poster program and in company publications. See Figure 1.

There have been installed automatic combustible gas alarm systems to overcome one of the most hazardous of refinery conditions—that of combustible gas concentrations in confined spaces. This system was adopted following a costly explosion in the Cleveland refinery's gas compressor house some five years ago. Since installation the alarm system has given several warnings that prevented gas concentrations from reaching explosive limits. Refinery personnel had time in each case to take remedial action.

Four explosion-proof combustible gas alarms in the gas compressor house continuously sample the atmosphere at four points between pairs of compressors. Air samples, drawn into the instruments at a velocity of about ten feet

Figure 1. Safety hats proved their value at one Standard (Ohio) plant when a jagged piece of steel, weighing some nine ounces, was knocked off a tray casting as it was being hoisted to the top of a tower. The broken piece angled away from the tower and struck Foreman Chester Parks on top of his safety hat although he was standing about eight feet away from the tower, a distance normally considered safe. Even though the object fell 56 feet and made a three-quarter inch dent in the hat, he suffered only a slight scalp cut.

Figure 2. Combustible gas alarms have an indicating meter on the face of the instrument which shows the concentration of combustible gases at all times. When the concentration reaches a predetermined limit, 40 percent of the lower explosive limit, warning signals are activated as the meter needle is drawn by magnetic attraction to a contact point closing the warning circuit. Red lights flash on the instrument, and horns blow loudly in the compressor house.

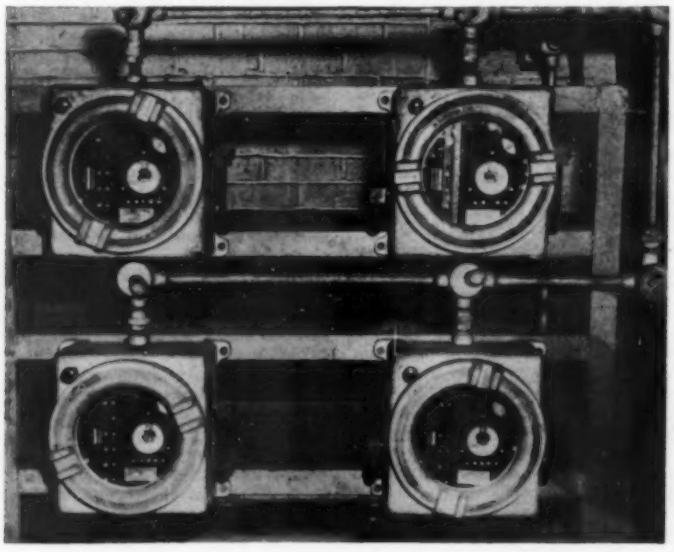


Figure 3. Portable explosimeters, powered by small flashlight batteries, make it possible to use a sampling line up to 50 feet in length to check recessed areas impossible to reach otherwise. Calibrated to give direct readings for many types of combustible gases and vapors, the instruments have proved to be advantageous for checking tanks, vessels, towers, manholes and other areas before welding or "hot work" is started.

per second from intakes slightly below floor level, are passed over a sensitized platinum filament. Resistance of the platinum wire is increased in proportion with the temperature rise resulting from this combustion and the electrical circuit between the two filaments is unbalanced in direct ratio. See Figure 2.

A similar protection system is installed in the butane pump house outside wall and air samples are piped to it. Besides these fixed instruments, the refineries use portable gas detection apparatus to check atmospheric conditions in suspicious areas. See Figure 3.

The American Petroleum Institute recommends methods of cleaning petroleum storage tanks involving removal of as much of the product from the tank as possible, blanking off all lines entering the tank, opening manholes, and forcing ventilation into the tank by using air movers until the tank tests vapor free. Tests are continued during the cleaning work. This method has been incorporated into the accident prevention program and as a general rule workers are not permitted to enter tanks until they have been tested and found gas free, or if they do enter, they wear host masks. See Figure 4.

Otto C. Haier, safety director of the manufacturing department, believes that "the availability of a well-balanced supply of emergency apparatus, and a staff of men thoroughly trained in how to use it, can turn a potential disaster into a minor accident." Accident prevention, however, is primarily a function of the degree to which safety consciousness has become ingrained in everyone's thoughts and actions, from the planners and the process and equipment designers to the operators and maintenance men, he said.

Figure 4. A tank cleaning crew is shown in this picture about to enter a large storage tank which had contained tetraethyl leaded gasoline at the Cleveland No. 1 refinery of The Standard Oil Company (Ohio). In accordance with safety procedures recommended by the supplier of the tetraethyl lead and the API for the cleaning of leaded gasoline storage tanks, the men are equipped with blower type hosemasks, rubber gloves and boots, light-colored coveralls. Air is supplied the men through hose lines by means of a blower located well away from the manhole at the bottom of the tank so that toxic vapors cannot be picked up. The men, through use of these hosemasks and blower, receive at all times a constant supply of fresh air under positive pressure. Double inhalation tubes, over the shoulders, insure a free flow of air even though one be constricted in a tight place.

Hydrogen Attack of Steel In Refinery Equipment

R. T. EFFINGER, M. L. RENQUIST, A. WACHTER and J. G. WILSON

THE MECHANISM by which hydrogen enters steel and destroys the structure of steel at low temperatures is discussed briefly. The effects of hydrogen penetration on the steel are described in more detail. Several illustrations are presented to show the various types of damage and the effects on the physical properties of steel. In addition, there is given a description of a destructive test made on a vessel while the steel was charged with hydrogen.

There follows a brief summary of the principal conclusions reached from an extensive investigation into the environmental conditions which favor hydrogen attack. Simplified flow diagrams of gas compression and fractionating plants are included in order to show the places where severe attack has been encountered.

The instruments and testing methods used in both plant and laboratory investigations are described, together with a brief report of the results obtained from these investigations. Finally, there is a discussion of the methods used to avoid hydrogen attack in catalytic cracking gas plants. The investigatory procedures used in this case may find application in other systems where hydrogen attack is encountered.

No doubt hydrogen attack of steel is much more prevalent than has been suspected heretofore. It is suggested that meticulous inspection of equipment is in order wherever hydrogen attack may occur. Use of standardized probes to detect conditions favorable to hydrogen attack is recommended. Continued free exchange of information between all companies concerned with this problem is urged.

Messrs. Effinger, Renquist and Wilson are with Shell Oil Company, the former in Martinez, Calif., and the latter two in New York. Mr. Wachter is with Shell Development Company, Emeryville, Calif. **Original presentation was to a corrosion session during the midyear meeting in May, Tulsa, of the API's Division of Refining.**

MANY INSTANCES of hydrogen attack of carbon steel in refinery equiment have been reported in the literature on this subject. Usually the attack has taken place in a manner which seemed unique to a particular piece of equipment, and so sporadically that it is difficult to establish definitely the conditions which caused the attack. Other authors have called attention to the serious nature of this type of attack, and have attempted to alert the industry of the necessity for further work. However, inasmuch as the economic justification for such endeavor was not too apparent, work of this type of necessity was diverted to problems of greater immediate value. Changes in processing conditions in some plants have brought about a condition favoring extensive hydrogen attack of steel equipment. It has become increasingly apparent that this is a pressing problem which requires the earliest possible solution.

Figure 1. External Blistering of a Vessel. Holes have been drilled into the blisters.

It is known that Shell Oil Company was not alone in experiencing difficulties with hydrogen attack, and the cooperation of other companies in the industry for an exchange of information was requested. Without exception, this was given generously and completely. It is a tribute to the entire industry that such free exchange of information can exist when pressing problems of this nature are confronted. As representatives of Shell, the authors wish to take this opportunity to thank all parties concerned for the valuable assistance rendered.

In return for this assistance, Shell management has instructed that the information now obtained be made public knowledge at the earliest possible moment in the hope that it may be of value to others. For this reason it is quite possible that this paper has had a premature birth and that further investigations maye be needed to confirm these experimental data. Nevertheless, the numerous requests for information which have been received indicate that it would be of greater value to release these data today rather than await the complete corroboration of this work by extensive plant experience.

Another reason for releasing the information at this time is that careful inspection of equipment in many refineries has shown that severe hydrogen attack is much more prevalent than was thought previously. Obviously a solution is of great importance; and the greater the talent brought to bear, the sooner will that solution be completed. It is hoped that others will extend their work on this subject, and

Figure 2. Internal Blistering of a Vessel. The head and some plates show only slight signs of blistering.

Figure 3. Closeup View of Blisters. Several small blisters in line indicate location of inclusions in the steel.

that the cooperation which has been so much in evidence will continue in the future.

Hydrogen Attack of Steel

This discussion is limited to hydrogen damage which occurs with the types of low-carbon steel commonly utilized in the construction of refinery process equipment and piping. It is also limited to the attack associated with aqueous corrosion, in which the hydrogen which penetrates the steel is a product of the electrolytic corrosion cell. In contrast to this type of attack is the attack associated with gaseous hydrogen at high temperatures, which has been thoroughly studied and reported by others.[13, 21]

It is common knowledge that hydrogen, under certain relatively low-temperature conditions, will penetrate and weaken the structure of steel, but that the environmental conditions under which this destruction takes place has not been well defined. Further clarification of these conditions is of pressing importance because available evidence shows that hydrogen attack in refinery equipment is increasing at an alarming rate. Furthermore, the problem does not appear to be one which can be solved economically by changes in the metallurgy of the steel. The greatest promise of solution seems to be in changing the environmental conditions so as to permit the use of ordinary grades of steel. It is believed that this objective can be realized if more complete understanding of the phenomena is obtained.

The work undertaken has already resulted in marked reduction of damage to steel equipment in the environments encountered to date, and it affords the means of studying environments which may present themselves in the future.

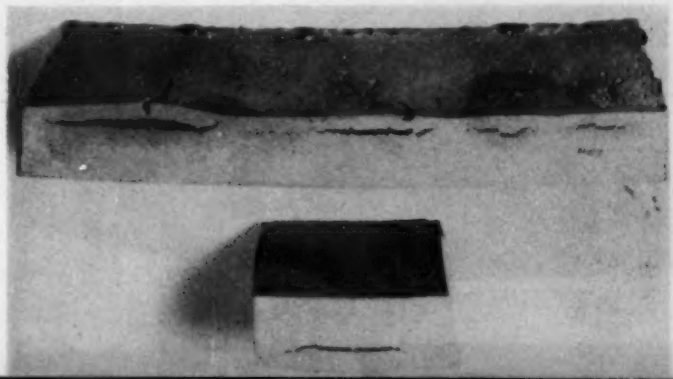
I. Mechanism of Hydrogen Penetration

The solubility of hydrogen in steel is appreciable, and it increases with an increase in temperature. The rate at which hydrogen diffuses through steel depends on its state. Molecular hydrogen diffuses through steel very slowly, if at all. Atomic hydrogen diffuses through steel very readily. It is believed that the manner in which hydrogen leaks out of a blister over long periods of time probably results from the fact that hydrogen dissociates to a limited degree at any temperature, and that the atomic hydrogen thus formed leaks off—this process continuing until the pressure is lost. It is also possible that even molecular hydrogen can diffuse through steel, but at a very low rate. For these reasons it is clear that molecular hydrogen, which may be a component of the process streams, plays no part in the attack of the steel; the harmful hydrogen is the dissociated hydrogen present on the corroding surface of the steel. One factor is certain, and it merits emphasis, viz.: dissociated hydrogen can leave steel as well as enter it. If the rate at which hydrogen enters steel is greater than the rate at which it leaves the steel, internal pressure will build up within the steel until either these rates become equal or the steel ruptures. The pressure required to rupture the steel depends on the strength of the steel which, in turn, depends on its homogeneity and physical properties.

The pressures which are required to rupture steel are of a very large order of magnitude, and the question naturally arises as to the source of such high pressures. If the steel of a vessel which operates under atmospheric pressure or under pressures of only a few hundred pounds can blister as a result of pressures of many thousands of pounds per square inch within the steel, there must be a source of energy to create such pressure. The pressure within the vessel itself is an insignificant factor. The source of this energy is the galvanic corrosion cells which exist on the surface of the steel. Steel also can be heavily charged with hydrogen by application of an external source of electric current.

Atomic hydrogen thus formed on

Figure 4. Section of Blistered Steel Plates. Prevalence of Blisters in Band between Rim and Core Areas.



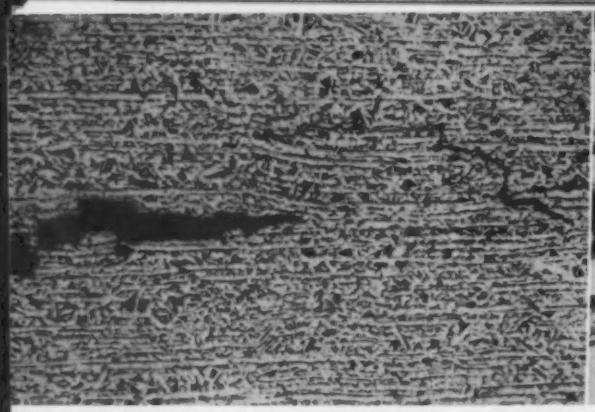


Figure 5. Photomicrograph through Blister. A Crack Which has not as yet become enlarged may be seen also.

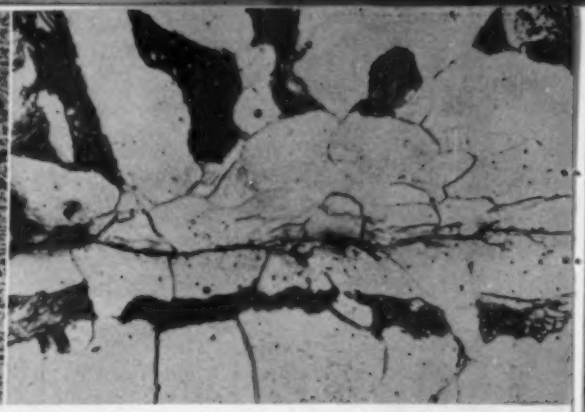


Figure 6. Photomicrograph in Which May be Seen a Crack Progressing from the Edge of a Blister.

corroding steel originates from the hydrogen ions in water. As a result of the action of such corrosion cells, a high concentration of atomic hydrogen exists on the corroding surface. From this surface it may diffuse into the steel. Donald P. Smith[21] states: "Diffusion of hydrogen cathodically liberated, which was first noted by Cailletet, 1868, has been repeatedly studied, and appears to differ from 'gaseous' type only because of the high pressure at which the diffusant enters the metal and the large concentration gradients which result." For hydrogen to diffuse into the metal, two conditions must be fulfilled simultaneously: 1) There must be maintained a high concentration of atomic hydrogen on the surface, and this normally occurs because of the continued activity of the corrosion reaction; and, 2) the surface of the steel must actively promote the acceptance of atomic hydrogen rather than catalyze the association of atoms to molecules of hydrogen gas. When hydrogen damage occurs in refinery equipment, the atomic hydrogen is supplied by the naturally-occurring corrosion cells. Obviously, elimination of the corrosion reactions will eliminate the supply of hydrogen, and thus stop the attack. Another alternative is modification of the cata-

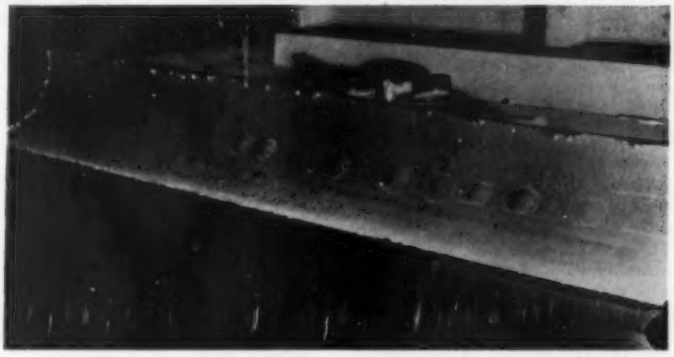


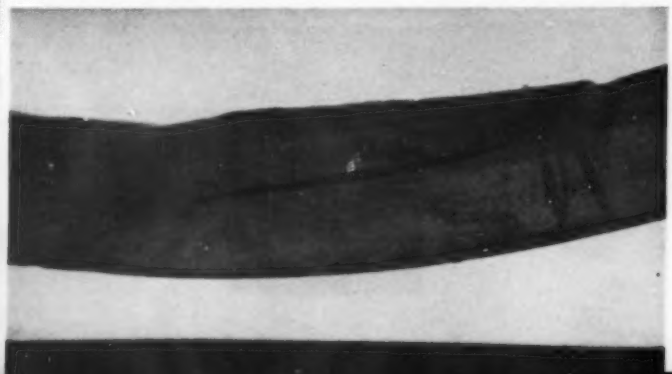
Figure 7. Blistering of Lap-welded Pipe. Blisters are oriented along the lap weld.

lytic nature of the steel surface so as to reduce the acceptance of atomic hydrogen by the steel.

Factors which influence the rate of corrosion reactions are more adaptable to study, and are more fully understood, than factors which affect the catalytic nature of steel surfaces. Empirically, it is known that traces of certain ions, such as sulfide and arsenate, promote surface conditions favorable to the acceptance of atomic hydrogen.[7, 8, 16] It is suspected that the absorption of surface films and their influence upon the hydrogen overvoltage may provide a clue to the factors which influence the catalytic nature of these surfaces.[21, 24]

The rate at which hydrogen diffuses through steel is affected by the condition of the metal. Highly stressed steel, such as cold-worked or welded steel which has not been properly annealed, will evidence greater penetration rates than steel in which internal stresses are of a lower magnitude.[1, 5, 6, 9, 21, 28, 29, 30]

Figure 8. Section through Lap of Welded Steel Pipe. A blister has formed in the lap weld. Note rupture of weld to inner structure of pipe.



II. Effects of Hydrogen Penetration on Steel

High internal hydrogen pressures in steel may cause blistering, fissuring, or embrittlement. The pressure which is built up in the steel will cause rupture at the weakest part. In dirty steel the weakest part may be an inclusion or lamination, whereas in clean steel the weakest part may be the slip planes or rifts within the grains themselves. Loss of ductility is caused by the high strain produced by hydrogen pressures which occur in submicroscopic voids. The hydrogen pressures which can be attained in discontinuities are of an extremely high magnitude, and far ex-

ceed the strength of the steel.

C. A. Zapffe and C. E. Sims[28] in discussing hydrogen blistering, fissuring, and embrittlement state: "Each type of defect depends upon a certain aerostatic pressure of occluded gas for its formulation. These pressures vary from several thousand atmospheres for embrittlement down to a fraction more than one atmosphere for blistering phenomena in paints and molten enamels."

Blistering

The occurrence of blisters in steel is the most striking demonstration of hydrogen attack, and often is the first outward indication that hydrogen damage is occurring. Unfortunately, by the time blisters are discovered, the steel has been damaged permanently.

The size and appearance of blisters in steel vary from almost microscopic bursts upon the surface to large swellings within the metal. Blisters up to several feet in diameter have been found. Photographs of typical blistered steel pressure vessels are shown in Figures 1, 2 and 3. Figure 4 shows a section through a typical piece of blistered plate, and Figures 5 and 6 are photomicrographs of typical small blisters. Similar blisters occur in pipe, particularly in lap-welded pipe. Figure 7 shows the internal appearance of a piece of lap-welded pipe which is blistered severely along the lap weld. A section through this blistered lap weld is shown in Figure 8. Evidence that seamless pipe also blisters is shown in Figure 9.

The mechanism for blister formation involves the conversion of atomic hydrogen to molecular hydrogen at internal discontinuities or inclusions within the steel, accompanied by a tremendous increase in volume. Most rolled steel plate is not homogeneous, and it contains traces of slag, oxide, sulfide, phosfide, gases, and other nonmetallic inclusions. In the process of rolling, these inclusions are squeezed into flat plates or bands within the steel. Such locations become the focal point for the formation of hydrogen blisters. Atomic hydrogen formed on the corroding surface diffuses readily throughout sound steel, and forms molecular hydrogen upon reaching these discontinuities. Tremendous pres-

Figure 10. Surface Fissuring of Steel Plate: Direction of the principal stress in vessel is transverse to most of the fissures. (Surface has been etched.)

Figure 11. Section of Fissured Plate Showing Subsurface Fissures. (Specimen has been etched.)

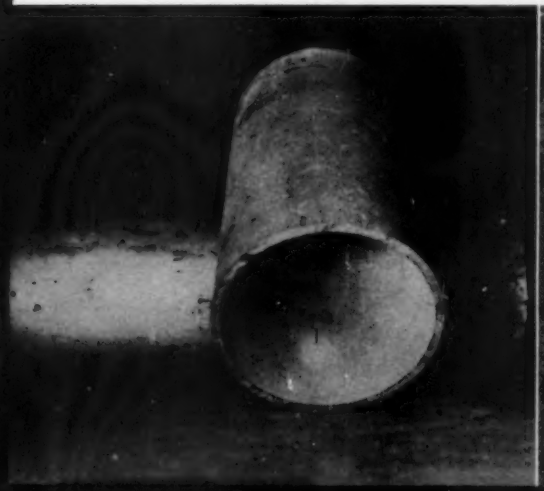


Figure 9. Blistering of Seamless Pipe. A number of blisters are present, oriented in a spiral pattern. (Courtesy, Cities Service Co.)

Figure 12. Etched Weld in Steel Plate Showing Fissured Weld Metal.

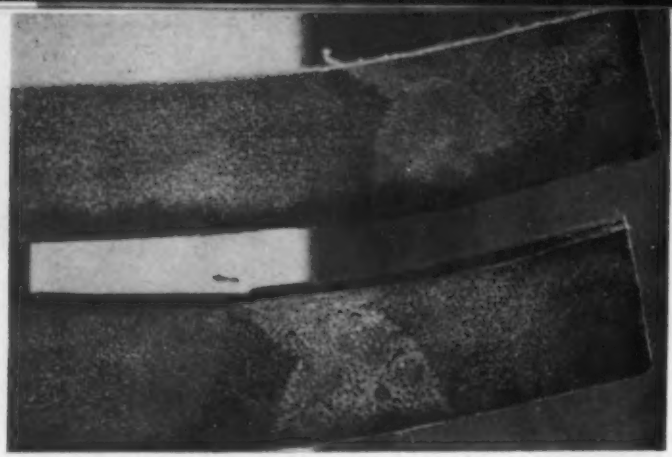


Figure 13. Section through Steel Plate in Figure 12 Showing Fissures in and Adjacent to the Weld.

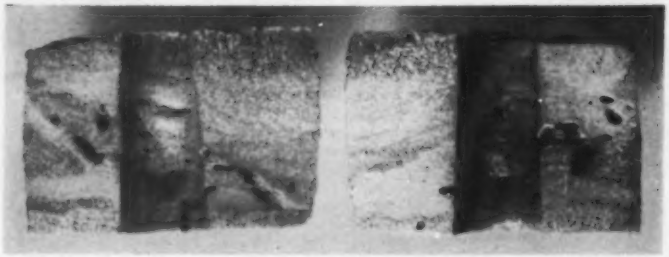


Figure 14. Trepanned Section through Cracked Weld.

sures are exerted which cause the steel to rip and tear along the relatively weak junctions of the non-metallic inclusions. As a result, the steel is forced outward by the accumulating pressure to form the convex surface of the blister. The location and size of such blisters depend upon the locations and size of the inclusions in the steel plate. In plates rolled from rimmed steels, blisters often occur at the junction of the rimmed and core areas—which, in plates of this type, is the area of maximum inclusions.

The pressure inside blisters has been measured at several thousand pounds per square inch.[2, 29] Analysis of the gas from within blisters confirms that it is pure hydrogen.

Although the hydrogen gas within blisters is essentially trapped, there is a very slow rate of hydrogen escape. Instances where vessels have blistered and subsequently been removed from the corrosive environment show that pressure inside the blisters is dissipated over a very long period of time.

Both rimmed and deoxidized grades of low-carbon steel plate have been observed to blister — although, as would be expected, the cleaner deoxidized steels blister less severely than the dirtier rimmed steels.

Fissuring

Inspection of many vessels has indicated that, even when blisters are not in evidence, a fine pattern of hairline cracks may develop upon the surface exposed to the corrosive environment. microscopic examination of steels from corroded vessels show small subsurface fissures roughly perpendicular to the surface, but with no visible evidence upon the surface of the steel. These surface and subsurface cracks are not confined to the plates which exhibit blistering, and occasionally are the only evidence of hydrogen attack. Photographs of fissured plate are shown in Figures 10 and 11, and photographs of similar damage to welds are shown in Figures 12, 13, and 14. Photomicrographs of subsurface fissures are shown in Figures 15 and 16. Figure 17 shows a bend test bar removed from a fissured vessel, and demonstrates the stress-concentration effect of a fissure upon the strength and ductility of the steel.

Fissures are normally oriented perpendicular to the direction of maximum stress, and thus have a maximum effect upon the strength of a pressure vessel. These observations parallel those of C. A. Zapffe and C. E. Sims with regard to flaking and fissuring.[29] These authors state: "Aerostatically stressed by the accumulating gas, these rupturing areas should be expected often to orient themselves with externally applied stresses, as an aerostatic stress operates equally in all directions, and rupture will lie in the resultant of all stresses."

It is the authors' opinion that the insidious manner in which fissures occur and the difficulty in their detection makes this type of defect the most serious which results from hydrogen

Figure 15. Photomicrograph Showing Fissures in Steel Plate.

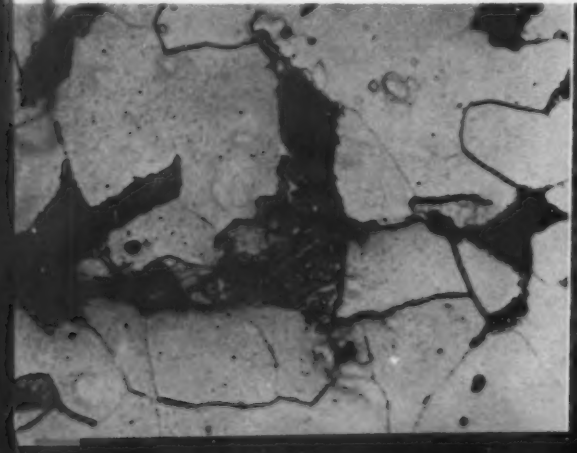
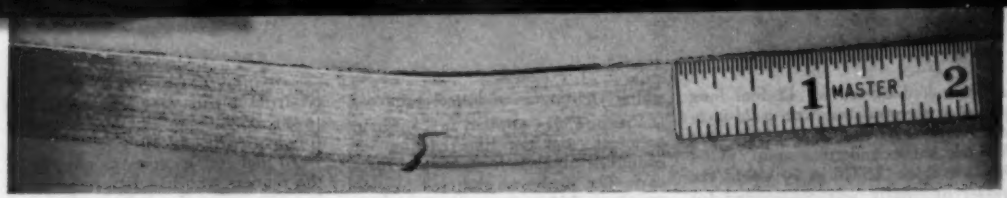


Figure 16. Photomicrograph Showing Subsurface Fissures in Steel Plate.



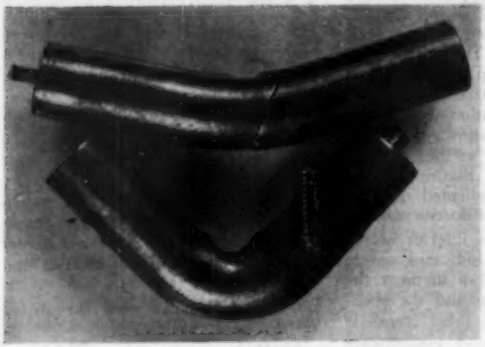


Figure 17 (above). Section of Fissured Steel Plate Which has Been Bent. Failure at the fissured surface is shown.

Figure 18 (left). Loss of Ductility in Steel. One 5/16-inch bar was bent immediately after it had been charged with hydrogen.

attack. Some success in revealing fissures by magnetic-particle inspection has been realized. Proof pressure-testing of vessels is resorted to in many cases. Development of an improved inspection technique for this type of defect is definitely needed.

Loss of Ductility

When steel is penetrated by hydrogen, it suffers loss of ductility. Inasmuch as the diffusion rates of atomic hydrogen into and out of steel are about the same, the loss of ductility of a piece of steel exposed to corrosive conditions may not be detected if the piece is tested several hours after its removal from the corrosive environment. This factor accounts for the apparent satisfactory ductility in specimens of steel removed from blistered vessels when they have been tested days or weeks after the vessel was removed from service.

To demonstrate this embrittling effect, a piece of steel must be tested by a method which utilizes a slow rate of deformation. Tensile, bend, and torsion tests amply demonstrate this loss of ductility. Testing methods which utilize a rapid rate of deformation, such as the notched impact tests, are insensitive to the loss of ductility associated with hydrogen.

The nature of the steel influences the degree of ductility lost when the steel is loaded with hydrogen. Hardened steels and cold-worked steels show a marked loss of ductility; whereas mild hot-rolled steels, such as are commonly used in pressure-vessel construction, show a less marked loss of ductility. The elongation of mild low-carbon steels which are free of hydrogen is in the order of 30 to 40 percent. When charged with hydrogen, the same steel may show elongation as low as 5 percent. A typical demonstration of the loss of ductility of mild steel is shown in Figure 18.

The loss of ductility in the type of mild steels used for refinery pressure-vessel construction might not be considered too serious. However, the combined effects of embrittlement and the high stress concentrations which result from fissuring or blistering are of much concern.

Materials for Construction

Refinery pressure vessels and tanks are constructed predominantly of rimmed steels corresponding to ASTM Specifications A 285 and A 7. As mentioned previously, these rimmed steels are particularly susceptible to hydrogen blistering. Killed steels corresponding to ASTM Specifications A 201 and A 212 are less susceptible to blistering, and in the past these killed grades of steel have been recommended for refinery pressure-vessel construction where blistering is encountered. However, it is now known that the use of killed steels does not provide complete assurance that blistering will be avoided because experience with these steels indicates that they will blister, but at a much slower rate than with rimmed steels. Furthermore, killed steel will fissure and lose ductility in corroding environments which favor hydrogen penetration.

Both seamless and welded pipe is subject to hydrogen attack in the same manner as equipment fabricated from rolled plate. The effect of hydrogen penetration may be much more serious in welded pipe than in seamless pipe because of discontinuities and imperfections which may exist in the weld. Lap-welded pipe is particularly objectionable. The inspection of pipe for hydrogen damage is extremely difficult, and for this reason alone it is of added importance that the source of the damage be eliminated.

Alloys, such as monel or Type 316 stainless steel in either solid or clad construction, have been used to avoid hydrogen damage. The use of these alloys is effective because of their specific resistance to the common environments in which hydrogen damage occurs. Very little is known regarding the effects of hydrogen at low temperature upon these alloys; but it is suspected that, under conditions in which these alloys experience slight corrosion, hydrogen attack may still prevail. The use of alloy construction is expensive, and the replacement of a major portion of a plant with alloy involves a prohibitive cost.

Surface coatings which satisfactorily shield the steel from the corrosive environment should be effective in avoiding hydrogen damage. Thin protective coatings, such as the common proprietary plastic enamels, have been tried. These were found to be effective only in part because lack of adhesion and unavoidable holidays permitted the steel to come in contact with the corrosive environment. Massive concrete linings have been quite effective in protecting steel; but, when hydrogen attack is encountered, it becomes impractical to provide this type of coating for the inner surface of all vessel and interconnecting piping. For these reasons, it is concluded that protective coatings are useful only as a stop gap in the solution of this problem.

In view of the impracticability of solving the problem of low-temperature hydrogen attack on steel by changes in the specifications of the steel or by the use of surface coatings, it becomes apparent that elimination of the source of the offending hydrogen provides the only practical solution.

Destructive Test of a Blistered Vessel

Evaluation of the effects of hydrogen damage upon the strength of pressure-containing equipment is exceedingly complex, and it is not adapted to simple mathematical analysis. For these reasons it was deemed advisable to subject a blistered pressure vessel to a destructive hydrostatic test and observe the mode of failure.

The vessel selected for this test was

a 54-inch-diameter by 12-foot-long pressure accumulator, with a 24-inch-diameter sump. The shell plates were 5/8-inch thick and the sump plates 1/2-inch thick ASTM A-70 steel. The vessel originally was constructed for a maximum allowable working pressure of 200 psi., with a 1/8-inch corrosion allowance. It was removed from service because of severe blistering of the heads and shell, even though it had not been thinned appreciably by corrosion.

As the vessel had been stored out of service for a period of approximately three weeks prior to the test, it was assumed that during this storage most of the hydrogen had escaped from the steel. To recharge the steel with hydrogen, the vessel was filled with an aqueous solution known to promote hydrogen penetration. The procedure consisted of filling the vessel with water to which concentrated sulfuric acid had been added so as to reduce the pH to approximately two and then saturating this water with hydrogen sulfide.

To detect when the steel in the vessel was again charged with hydrogen, four 7-inch-diameter steel pads were welded to the outside surface and vented through a short piece of metal capillary tubing to gas-collecting tubes. When hydrogen was detected in the gas emitted from under these pads, the vessel was considered ready for test. The corrosive solution remained in the vessel throughout the pressure test. Prior to the test, the external surface of the vessel was sandblasted and coated with a lime wash so as to detect the pressure at which yielding of the steel occurred.

Pressure was applied in 25-psi. increments, and the lime coating was examined at each increment of pressure. The steel was observed to yield at about 500 psi., and rupture occurred at 800 psi. The predicted yield pressure for a sound vessel was 525 psi., and the predicted rupture pressure was 1050 psi. The rupture occurred as a 2-inch split in the sump near the weld which attaches the sump to the shell. The condition of the vessel prior to the test is shown in Figure 19, and the rupture at the point of failure is shown in Figure 20. External observation indicated that the steel had ruptured in a ductile manner.

Examination of the interior of the vessel after testing indicated severe cracking of the steel plate near the junction of the sump and the shell. The appearance of these cracks is shown in Figure 21. A photomicrograph of a section through one of the cracks is shown in Figure 22. Critical examination of the steel in the sump area indicated that it had been severely fissured, but not blistered. The failure and crack formation shown in these photographs originated from the type of surface and subsurface fissures previously described.

III. Survey of Plant Operating Conditions

Early in this investigation it was suspected that hydrogen attack had been considerably influenced by environment, and it seemed reasonable to suppose that a study of process conditions under which blistering had occurred might well provide the clues to an explanation of, and a remedy for, hydrogen attack.

To that end, as many as possible of the refiners who had reported blistering were visited, and from them was obtained all available information on the accompanying process conditions. This survey indicated that hydrogen blistering, fissuring, and embrittlement have been experienced in the following operations:

1) Natural-gasoline plants which process sour gas and gasoline.

2) Storage tanks used for sour gases and gasoline.

3) Gas-recovery and fractionation plants associated with catalytic cracking units.

4) Hydrogen-sulfide removal and disposal plants.

5) Storage tanks used for strong sulfuric acid.

6) Hydrogen-fluoride alkylation plants.

By far the largest economic loss caused by hydrogen damage is experienced in environments where hydrogen sulfide is encountered (the first four conditions enumerated above). Only a few cases of hydrogen damage in sulfuric-acid storage tanks and in hydrogen-fluoride alkylation plants have been reported. Although these latter instances of hydrogen damage are important and deserve study, the pressuring problems were those encountered in sour hydrogen-sulfide environments; thus efforts were concentrated upon this phase, with particular emphasis upon controlling the attack in catalytic cracking gas plants.

Figure 19. Vessel in Which the Steel has been Charged with Hydrogen, Ready for Destructive Test.

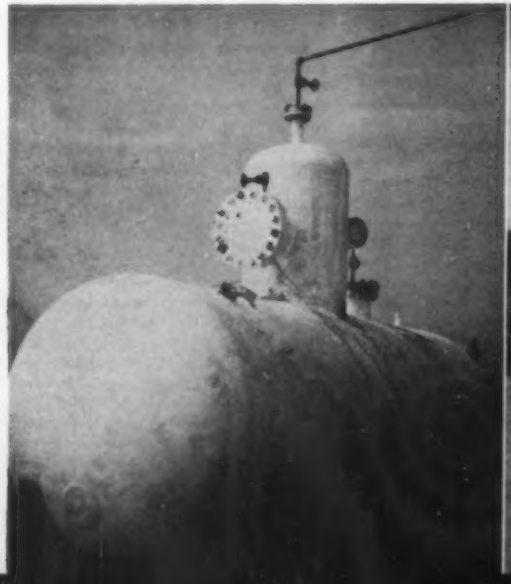


Figure 20. Vessel after Destructive Test Showing Location of Rupture.

Hydrogen Damage to Catalytic Cracking Gas Plants

A simplified flow diagram for a typical catalytic cracking gas compression plant is shown in Figure 23, and a simplified flow diagram for an absorption and fractionating plant is shown in Figure 24. Individual plants may vary in details of equipment and in operation; but these flow diagrams represent the simplified basic features of most plants, and they are presented to indicate the locations where hydrogen blistering, fissuring, and embrittlement are likely to occur. They are presented as a composite of the experience of various refiners. No single plant has experienced hydrogen attack in all of these locations.

When all the evidence from this survey had been accumulated and studied, certain facts were established on which a program could be based as follows:

1) Hydrogen attack is experienced only in environments where free-water phases are known to exist, regardless of the temperature and pressure. In no instance has low-temperature hydrogen penetration, blistering, fissuring, or embrittlement been discovered where an aqueous phase is not present.

2) In all locations where hydrogen attack occurs, hydrogen sulfide is a component of the process stream. However, no correlation exists between the concentration of hydrogen sulfide and the severity of hydrogen attack. In some locations where high hydrogen-sulfide concentrations are encountered, there is no evidence of hydrogen damage.

3) The attack is observed in environments which have a wide range of pH. In some instances the damage is severe under both acidic and mild-to-strongly-alkaline conditions. Several instances indicate that the attack occurs in strong sodium-hydroxide solutions.

4) Cyanides are suspected to be promoters of the attack, from the following observations:

a) At many locations where the attack is severe, blue-grey deposits are formed in the equipment; and, when these are washed from the vessels and allowed to stand in the air, a deep blue (prussian blue) stain develops. Analysis of these deposits confirms that they are ferrocyanide. In other locations the distinct odor of cyanide is detected in the water layers drained from hydrogen-damaged equipment.

b) Blistering has occurred in the stripper columns of several diethanolamine plants for hydrogen-sulfide removal, and has not occurred in other similar plants. Only in those plants where blistering occurs were cyanides reported.

c) Blistering and related hydrogen damage appear to be more severe in plants with heavier feed stocks, such as those prepared by solvent-de-asphalting of crude or by deep flashing, or where entrainment of heavy ends is excessive. It is established that nitrogen compounds are more prevalent in heavy crude fractions and that, in catalytic cracking operations, they crack to cyanides.

5) The concentration of water-soluble components appears to be critical. In numerous instances the streams are contacted with minor quantities of water in order to reduce the formation of plugging deposits. Following these light water-washing operations, hydrogen damage appears to increase. It is thus suspected that a critical balance of water-soluble components may exist under which the attack is neligible, and that this balance may be upset by removing only part of the water-soluble components.

6) An extensive water wash has the effect of removing the promoting agent or of reducing it to a safe level. Streams which had been contacted thoroughly with large quantities of water lose their ability to promote hydrogen attack.

7) It is known that active promoters are selectively extracted into the water phase. In one plant in which extensive water washing is practiced and in which no blistering is found in the gas plant itself, the water drainings from the unit are stripped of obnoxious gases in an atmospheric tower before the water is rejected to the sewer. The column, condenser, and overhead accumulator for this stripping operation blistered severely. This particular instance warranted special study, because the blistering occurred in the presence of large quantities of ammonia and under conditions of high pH. The attack was particularly virulent. Steel pads which were welded to the outside of the condensate accumulator, and which were fitted with a pressure gage, showed a hydrogen-pressure buildup in excess of 200 psi. in less than four days.

8) The active environment follows the light hydrocarbons throughout the process plants. The attack is severe in unstabilized gasoline streams but, after stabilization, occurs only in equipment which handles the butane, propane, and ethane fractions. No damage appears in subsequent equipment which processes or stores the stabilized gasoline.

9) In catalytic cracking plants the active components are produced in plants which use either natural or synthetic catalyst. Minor variations in the methods of catalyst regeneration have no marked influence upon the activity of hydrogen penetration in the gas plants which process the products of catalytic cracking.

10) In general, the corrosion rates at locations where hydrogen damage occurred are of a moderate to low order of magnitude. Many are in the order of 0.001 to 0.010 inch per year. However, in isolated cases, as in the sour-water stripping column mentioned previously, severe hydrogen damage is associated with high corrosion rates.

11) The pattern of hydrogen damage in any one plant is erratic. In some locations blistering occurs only in certain condensers in banks of several parallel stacks. In others there is

Figure 21. Interior of Ruptured Vessel Showing Cracks which Originated at the Surface Fissures.

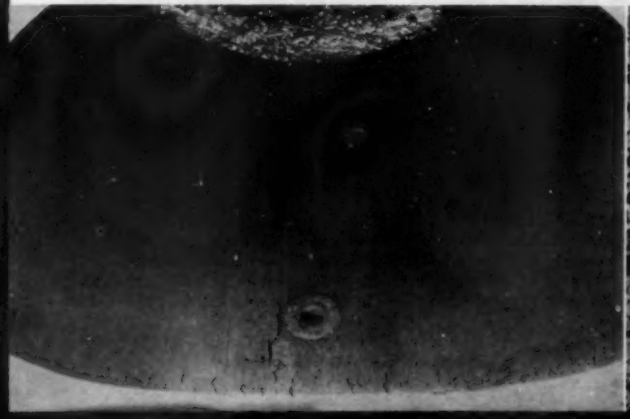
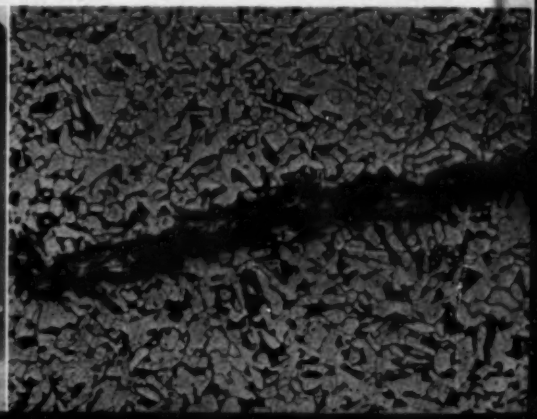


Figure 22. Photomicrograph through Crack in Steel from Ruptured Vessel.



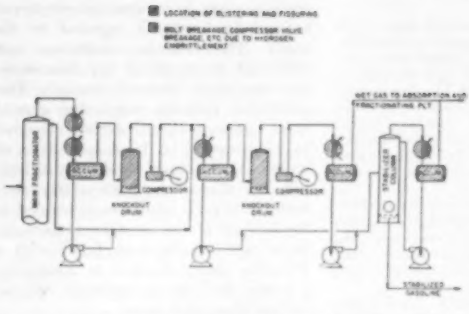


Figure 23. Simplified Flow Diagram for Typical Catalytic-Cracker Gas-Compression Plant.

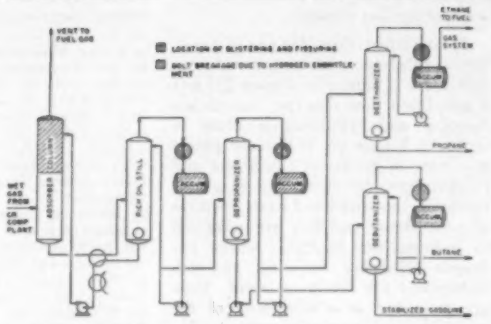


Figure 24. Simplified Flow Diagram for Typical Gas-Absorption and Fractionating Plant.

no evidence of blisters in condensers, but the accumulators are severely attacked. Furthermore, the pattern of attack in any one vessel is erratic. Examination of adjacent plates in the same vessel frequently shows one to be blistered severely with no evidence of blistering on the other. In general, the heads of pressure vessels are less severely attacked than the shells. More careful examination of some of this equipment has shown that, even though no blisters are found, the plates are badly fissured.

12) The pattern of attack inside a pressure vessel often appears to be associated with the phases in contact with the steel. In general, although there are exceptions, blistering is more severe in the vapor space of accumulators than in the aqueous layer which accumulates in the bottom of the vessel. In spherical vessels and in horizontal cylindrical accumulators, maximum damage often occurs in a band oriented 30° to 45° from the vertical, and in the bottom half of the vessel.

13) Tempered-alloy and high-carbon steels are more subject to embrittlement than are low-carbon mild steels. Tempered-alloy bolts, springs, and compressor valves are particularly susceptible to embrittlement when they are exposed to corrosive conditions which promote hydrogen penetration. In several instances where bolt failures have become intolerable, replacement of tempered-alloy bolts with mild steel bolts has been advantageous.

14) The austenitic grades of stainless steels are satisfactorily resistant to the corrosive environments which promote hydrogen penetration in carbon- and low-alloy steels. The ferritic grades of stainless steels are not suitable, as these steels become severely embrittled when they are exposed to environments conducive to hydrogen penetration.

15) Protective linings have been tried, but no really satisfactory enamel type of lining adaptable to field application has been found. Cement and concrete linings inside accumulators and tanks are used with success, but application is limited.

Inspection of equipment reveals that hydrogen attack is much more prevalent than has been suspected heretofore. The authors strongly recommend that inspection departments search carefully for signs of hydrogen damage. Although most cases of hydrogen attack which have been reported refer to blisters of steel plate, it is now known that, even where there is no evidence of blisters, many plates are fissured. It is most likely that meticulous inspection of vessels will reveal hydrogen attack not suspected previously.

IV. Instruments and Testing Methods

Several means of investigating the environments which cause hydrogen attack may be followed. Among these are 1) chemical analyses of the process streams from samples taken at a time when it is known that hydrogen is penetrating into the steel vessels; 2) use of the plant itself as an experimental unit in which processing conditions can be varied and the effect of such variations in producing hydrogen penetration determined; and, 3) synthesizing of processing streams in the laboratory in which one component can be studied at a time and by determining the effect of such changes in the rate of hydrogen penetration of steel. All these approaches have one factor in common, viz.: it is necessary to have an instrument to determine the effect of the environment on penetration of hydrogen through the steel.

Hydrogen Probes

Early in this program it was recognized that there was need for an instrument for measuring the activity of environments which promote hydrogen penetration. Previously the rate of hydrogen penetration had been measured by observing the pressure buildup under reinforcing pads or inside steel thermowells. However, these methods had required periods as long as several months before pressure increases were significant, and they had not been sensitive to daily changes in the environment. Therefore, work was concentrated upon developing techniques suitable for the evaluation of daily changes in the activity of the plant environments.

It was first thought that measurements of physical properties, such as magnetic permeability, conductivity, or ductility in steel, might provide a means for the evaluation of the hydrogen content.[21] Preliminary tests indicated that, although these properties varied with hydrogen content, the methods lacked sensitivity and reproducibility.

Further work was focused upon developing a membrance type of hydrogen-accumulating device with the required sensitivity. Several varieties of probes were developed. The instrument shown in Figure 25 was finally selected for standardization purposes. The details of construction for this probe are shown in Figure 26. It combines the features of adequate sensitivity, ruggedness, simplicity, small size, and economical construction. Sensitivity is acquired by the use of a thin-walled small-volume probe which permits rapid hydrogen penetration and a measurable pressure change with only a small accumulation of hydrogen. The probe illustrated is fitted with a pressure-indicating gage. However, the same probe is adaptable to continuous record by the elimination of the screwed tee and gage, and by the brazing of a capillary-tube lead from a pressure recorder directly into the small-diameter vent hole in the central rod. In some locations it has been found advantageous to modify the probe so as to permit inserting and withdrawing the instrument through a

stuffing box while the vessel is under pressure. Such a probe is shown in Figure 27.

Prior to use these probes are tested for leaks either by pressure testing with hydrogen at 100 psi., or by evacuating to about 0.1 mm. and observing any loss in pressure or vacuum after 24 hours. It is important that the probes be free of leaks because the rate of accumulation may be only a few milliliters of hydrogen per day. The volume inside the assembled probe is determined by applying two atmospheres of pressure and measuring the volume of gas released when the pressure is reduced to one atmosphere. Knowing the volume of the probe and the area and thickness of the thin wall, it is possible to express the activity of an environment in empirical units, and thus to compare probes which have slightly different dimensions. Experience with this instrument has indicated that a period of several days may be required for the probe to become stable. Thereafter the rate of pressure rise is closely related to changes in operating conditions.

Probes of this design have been extremely useful for the detection of environments which promote hydrogen penetration, and for the evaluation of the changes in operating conditions which influence the rate of hydrogen attack. In several cases probes had actually detected active hydrogen conditions before severe blistering or fissuring was evident. In one refinery the equipment associated with the gas plant was inspected, and no blisters were found. Probes were installed at susceptible locations throughout the plant, and appreciable rates of hydrogen penetration were observed in one condenser. The unit was taken out of service again and, after sandblasting, minute blisters were observed on the steel. Operating conditions were then altered to prevent further damage.

In these investigations it was found that more sensitive probes could be constructed by making the area larger, by using cold-rolled in place of hot-rolled steel tubing, and by utilizing sensitive pressure-detecting devices. One such probe consisted of a thin-walled steel tube sealed to a Pirani vacuum gage. This probe was so sensitive that immersion for even a brief period in distilled water showed an indication of hydrogen penetration. Some of these more sensitive probes have particular application in laboratory work.

The Determination of pH

The pH of aqueous phases in contact with the steel is an important factor in the evaluation of the environment, but accurate determinations of pH inside vessels which operate at a pressure of several hundred pounds per square inch are difficult. Ordinary glass electrodes are incapable of withstanding these pressures, and colorimetric methods are inaccurate when the water is discolored. The pH of water drainings has been approximated by withdrawing a sample, under pressure, into a clean gage glass in which indicators had been placed. Such measurements show that, in most cases, the water drainings from the bottom of accumulators are neutral to slightly alkaline.

Inasmuch as blistering has been observed to be more intense on the upper side walls of pressure vessels exposed to hydrocarbon liquid and vapor phases, it would be informative to have the true pH of the water droplets which condense upon the steel in these locations. Several attempts have been made to obtain this information, but without success. Analyses of the gas in some instances have shown negligible quantities of ammonia and appreciable acidic components such as hydrogen sulfide, carbon dioxide, and low molecular-weight organic acids. It would seem that, although the water drainings may be neutral to slightly alkaline, the water droplets which condense in the vapor phase may be acidic in reaction.

Figure 25. Assembly of Hydrogen-Activity Probe Showing Probe, Bleed Valve and Pressure Gage.

Analysis of Process Streams

The sampling and analysis of process streams are fraught with difficulties which may not be readily apparent. In withdrawing samples of either hydrocarbon or aqueous phase from pressure equipment, elaborate systems are required to avoid the loss of volatile components. The determination of the true composition of the phases which exist inside a steel pressure vessel is further complicated by the fact that some of the compounds undergo transformation when the pressure is reduced, or between the time of sampling and analysis. Analyses for cyanide and cyanide complexes are particularly difficult because cyanides form esters, they hydrolize, or they react with other components so readily that a true evaluation of the cyanide, cyanogen, or cyanide complexes which are in contact with the steel is virtually impossible. Improvement of the techniques of sampling and analysis of these streams is a problem which requires solution.

V. Laboratory Investigations

The environments in plants where blistering, fissuring, and embrittlement are encountered are so complex and variable that intensive plant studies of the chemical and physical factors which influence the rate of penetration are not feasible. These factors are being investigated in the laboratory. Particular emphasis has been placed upon the influence of minor components in the environments where hydrogen damage occurs. It is believed that an understanding of the role played by these minor components may explain why severe hydrogen penetration occurs in some hydrogen-sulfide environments and does not occur in others.

In the majority of the laboratory experiments, the corrosive media have been prepared synthetically from pure chemicals. In early experiments the loss in ductility of steel torsion test bars was used as a measure of the activity of the environment. Subsequently hydrogen-collecting devices similar to those used in plant tests, but designed for increased sensitivity, were found to be more suitable because they permitted a continuing study of a given environment.

The Effect of pH

Early in this investigation it was confirmed that hydrogen sulfide dis-

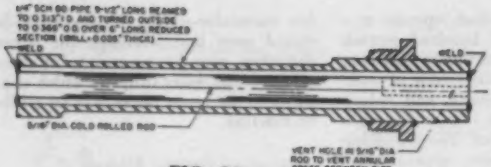


FIG. 26

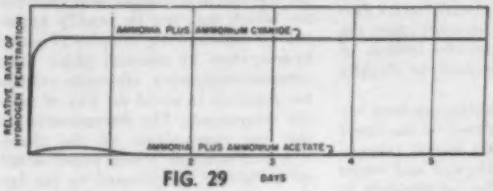


FIG. 29

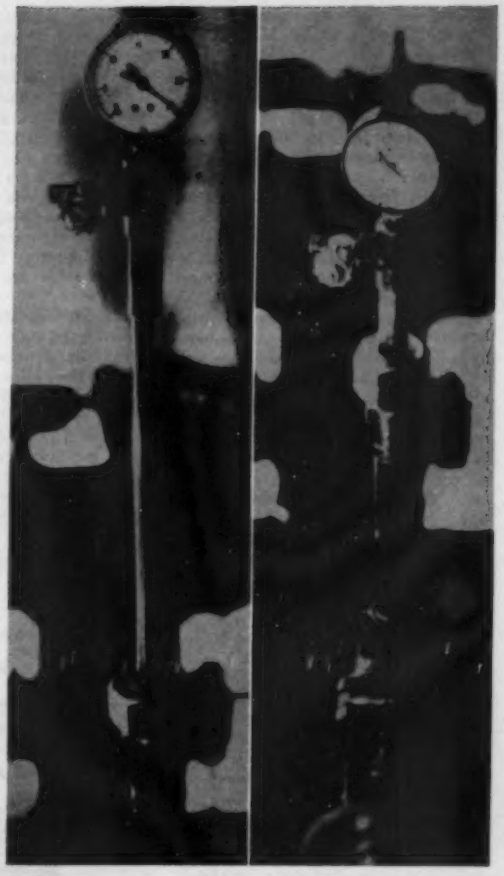


Figure 26 (top). Schematic Sketch of Probe.

Figure 29 (bottom). Rate of Hydrogen Penetration Vs. Time.

Figure 27 (right). Probe for Use through Stuffing Box.

solved in water, or that a wet atmosphere which contains hydrogen sulfide, is an active environment for the promotion of hydrogen penetration. However, in tests extending over several days, it was found that the rate of hydrogen penetration decreased markedly. This decrease in activity was associated with the buildup of iron-sulfide deposits on the steel surface. Reducing the pH of the hydrogen-sulfide solution by the addition of acidic material, such as acetic or formic acid, increased the rate of hydrogen penetration. Increasing the pH by the addition of very small amounts of ammonia or other alkali resulted in almost complete elimination of hydrogen penetration. These effects are illustrated in Figure 28.

This series of tests explained why some hydrogen-sulfide-rich environments were active in promoting hydrogen penetration and why others were inactive. However, severe hydrogen-penetration damage was being experienced in several locations where the pH was high. In fact, strong alkalies were present. It was observed in the laboratory experiments that the activity increase which had been observed when the solutions were made acidic was associated with removal of iron-sulfide scale. Therefore, it was postulated that other reactions which would destroy the sulfide scale under alkaline conditions might promote hydrogen penetration. One such reaction which had been observed in the plant was the formation of iron-ferrocyanide complexes. Therefore, later work was concentrated upon a more complete investigation of the influence of cyanide compounds.

Effect of Cyanide Complex Formation

Investigation of the influence of high concentrations of cyanide ion revealed that, although hydrogen cyanide was generally inactive in influencing the rate of hydrogen penetration, cyanide salts caused a marked effect. This is shown in Figure 29. The activity shown is apparently caused by cyanide ion; and, inasmuch as hydrogen cyanide is only slightly ionized, this component will have little effect in acid solutions. In alkaline solutions, however, sufficient cyanide ion is present to react with the iron sulfide and to lead to continued activity. This is a mechanism by which high rates of hydrogen penetration can occur in an alkaline environment such as that of the sour water-stripper column previously mentioned.

Still another effect of cyanide ion is illustrated in Figure 30. In this experiment, a probe was exposed to hydrogen sulfide and water for several days, and then a small amount of ammonium cyanide was added to the water. It was shown that the probe at first passed hydrogen readily. Then, as the sulfide film was developed, the rate of hydrogen penetration was reduced to a low figure. Immediately following the addition of the ammonium cyanide, the rate of penetration decreased to essentially zero, as would be expected, because the cyanide salt was alkaline in nature and raised the pH. Then, after some lapse of time, the rate of penetration increased sharply, and continued at a high level.

In these experiments the ferrous-sulfide coating was observed to dissolve with the formation of a blue-grey complex iron ferrocyanide on the steel. The laboratory observations thus parallel the experiences previously mentioned in catalytic cracking gas plants where cyanides, as evidenced by the formation of iron-ferrocyanide complexes, appeared to be closely associated with the incidence of hydrogen damage.

Further tests have shown that, for water solutions which contain hydrogen sulfide, the rate of hydrogen penetration in acidic environments is primarily influenced by the hydrogen displacement reaction between the steel and the acid—and, under strongly

acidic conditions, the iron-sulfide scale does not accumulate to appreciable thickness. In alkaline environments, the formation of ferrocyanide complex modifies the scale so as to permit the corrosion reaction to continue.

VI. Avoiding Hydrogen Damage in the Plant

From the accumulated data of plant experience and laboratory tests, it appears convenient to classify hydrogen-active environments as follows:

1) Environments in which relatively pure hydrogen-sulfide-water solutions are in contact with steel.
2) Environments in which hydrogen sulfide, water, and acids are present.
3) Environments in which hydrogen sulfide, water, cyanides, and ammonia are present.

In the first classification, continuing damage from hydrogen penetration is likely to be slight unless operating conditions are sufficiently fluctuating to damage the protective iron-sulfide scale formed. In these instances, addition of very small quantities of ammonia to the stream should be sufficient to increase the pH of the aqueous phase so that hydrogen penetration will not occur.

In the second classification, in which moderately strong acids such as formic, acetic, and similar acids are present, excessive quantities of ammonia may be required to raise the pH to safe levels. Furthermore, inasmuch as the solubility of ammonia in water is much greater than the solubility of the acidic components, it will be selectively extracted when water condenses from the stream. In an operating unit, re-injection of ammonia in several locations may be required. Obviously, the removal of water-soluble acidic components would be more practical. In a number of plants this is being accomplished by a thorough water wash of the hydrocarbon liquid and gas streams.

In the third classifications, in which cyanide and ammonia are present, it is usually true that the stream also contains appreciable quantities of acidic components. In any event, mitigation will be effected if cyanide, ammonia, and acidic components are reduced to a safe level. This is being accomplished by an extensive water washing of the gas streams. The determination of the required degree of water wash can best be guided by the use of hydrogen-activity detection probes located at suitable points throughout the plant.

Plant Applications

Specific application of these corrective measures has been made at one refinery. This case will be described in detail. Hydrogen blistering was first observed in this plant in December 1948, when severe blistering was discovered in the shells of four of six condensers located following the high-pressure stage of compression. In April 1949 blisters were discovered in the rich-oil still reflux condenser. During 1950, 14 additional cases of blistering were discovered throughout the gas-compression and gas-fractionation plant associated with the catalytic cracking plants. These later cases include condenser shells, accumulators, and one absorber column. This alarming rate of increase in blistering damage demanded immediate investigation and mitigation.

An attempt was made to correlate the increased rate of blistering with operating variables, and it was found that blistering became apparent coincident with the startup of a new deep flasher. At about this same time severe difficulties were experienced with the formation of plugging deposits which consisted of iron sulfide and iron ferrocyanide.

Several years previously another catalytic cracking gas plant had experienced similar plugging difficulties, and the problem was alleviated by washing the gas streams with water. Based on these data, water washing was tried on the plant just described by utilizing temporary facilities to inject approximately 20 gpm. of water into the gas streams which have a capacity of 25 million standard cubic feet per day. This reduced the plugging deposits, and operation of the water wash was continued in this manner for approximately six months.

In the meantime hydrogen-blistering damage was observed in several pieces of equipment. Therefore, two probes were installed in vessels where blistering had occurred. The probes were of cold-drawn steel tubing 12 inches long, 1 inch in diameter, with a wall thickness of ⅛ inch and were attached to a pressure gage through a piece of capillary steel tubing. After approximately 30 days hydrogen pressure began to build up in these probes, and it was observed that the pressure buildup would stop when the water-washing operation was discontinued. In the light of this and the experience of other plants where meager water washing apparently promoted blistering, it was decided to discontinue water washing until further information could be accumulated regarding adequate control of the blistering difficulties.

At this time the standardized probe previously described was developed and installed in critical locations throughout the gas and compression plants. These revealed that hydrogen activity was widespread throughout the plant, and that it was progressing even after water washing had been discontinued.

In an effort to alleviate the attack by raising the pH of the gas stream, a trial was made during which ammonia at the rate of 60 pounds per hour was injected into the gas ahead of the compressors. Measurements of the pH of the gas and water drainings indicated that much of this ammonia was being lost through extraction into the water phase drained from the accumulators following the compressors. Furthermore, vent gas lines became plugged with ammonium-carbonate deposits. Little or no ammonia was reaching equipment distant from the point of injection. In some equipment the rate of hydrogen penetration was reduced by this injection of ammonia; but, in other locations, the ammonia had negligible influence, or may even have increased the activity.

To investigate further the influence of ammonia, large quantities were injected into a column where the accumulator gas was strongly acidic and hydrogen penetration rates were high. In this instance, the test was conducted over eight hours; and it was observed that, when neutral conditions were maintained, pressure buildup in the probe stopped. After the ammonia injection had been stopped, only a few hours were required for pressure buildup to resume in the probe.

The water-wash facilities were revamped to permit the injection of a larger quantity of water at both the low-pressure condensers and at the high-pressure condensers. More complete water washing has eliminated hydrogen activity in most locations, and has substantially reduced the activity in others. The history of a typical probe record over these periods is shown in Figure 31. Further extension of water washing is planned so as to provide complete protection of the plant. It seems evident, from the experience in this plant, that protection of an entire gas-recovery system by water washing in only one or two locations is not feasible unless special facilities are provided to effect the complete removal of the offending components. This may involve the use of prohibitively large quantities of water. Apparently the concentration effect, which has been so evident throughout this investigation, becomes operative, so that process streams rendered inactive early in the flow scheme are reactivated as quantities and compositions change in subsequent fractionation steps. Thus a practical system of control would consist of a fairly heavy water wash of the gas

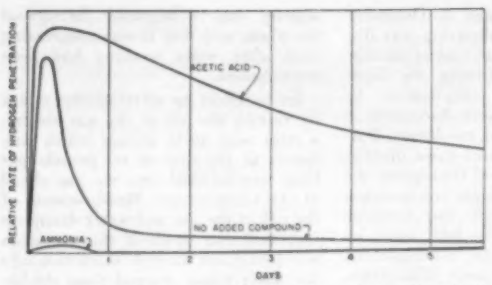


Figure 28 (above). Rate of Hydrogen Penetration Vs. Time.

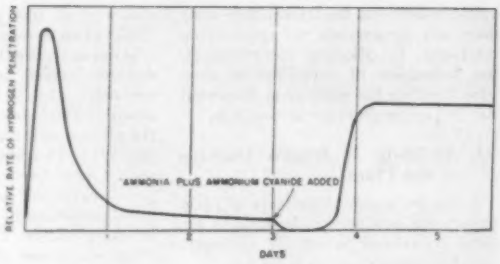


Figure 30 (above, right). Rate of Hydrogen Penetration Vs. Time.

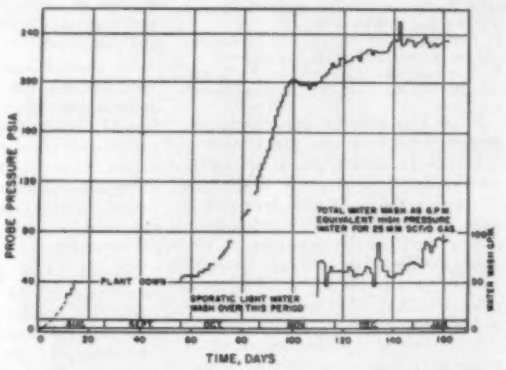


Figure 31 (right). Log of Pressure Buildup of Active Probe Showing Effect of Water Wash.

streams early in the plant flow, with additional washing at other downstream locations which are shown to be active by pressure buildup on probes. That such a system is effective has been demonstrated in one plant which has operated for some years on a deep-flashed high nitrogen-content feed. In this plant no evidence of blistering has been encountered except in the water stripper, where obnoxious gases are removed from the wash water. This stripper has been referred to earlier in this paper.

Recommendations

The authors have presented certain information which they believe to be timely and of general interest to the petroleum industry, and possibly to others. They do not presume to believe that this matter has been completely investigated; but they would like to present the results which they have developed to date in order to stimulate further work. If such additional work is undertaken, and if the results are pooled, it is certain that the objective of obtaining a fuller understanding of hydrogen attack of steel will be advanced. Hydrogen attack of steel is probably much more prevalent than has been suspected. Use of probes, as well as careful inspection of equipment, should be undertaken wherever there is any possibility of hydrogen attack. Standardized probes are recommended to facilitate comparative evaluation of probe activity in all kinds of environments.

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AS NOTED in connection with the author's article "Precise Fractional Distillation Analysis," published in the April, 1951, issue of PETROLEUM REFINER, the satisfactory operation of light hydrocarbon processing plants is closely related to the convenience and accuracy of the means available for analyzing the compositions of the various charge, product, and intermediate process streams.

The article printed last month presented a theoretical investigation of low-temperature fractional analysis apparatus and methods. This article, delivered as a talk before the recent Natural Gasoline Association of America meeting in Tulsa, supplements the earlier article with a treatment of the fundamentals of analysis apparatus operating technique and of the causes and cures of errors.

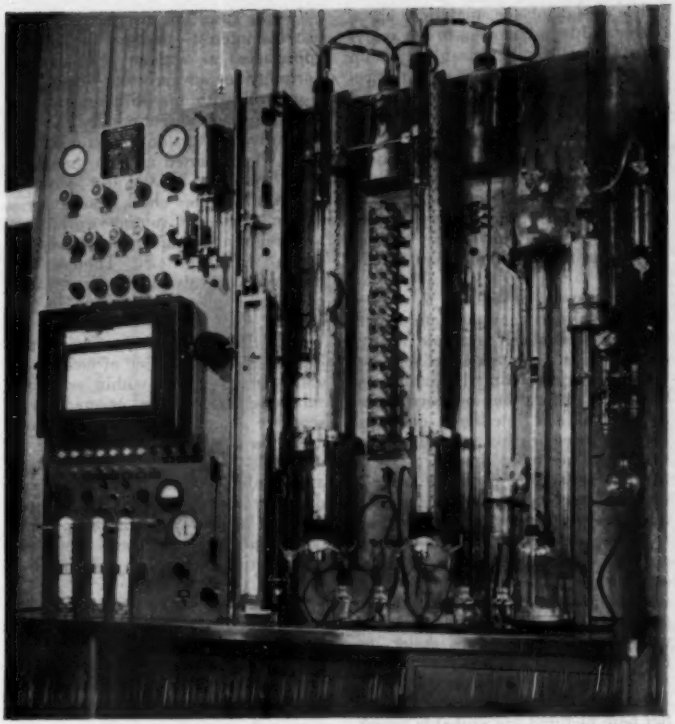

Figure 1. Photograph of Latest Electronic Hydrobot Low-Temperature Analyzer, with 0-2 MV Sensitive Second Temperature Range Recorder.

Low-Temperature Fractional Analysis of Liquids and Gases

Part II. Fundamentals of Operating Technique Causes and Cure of Errors

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LOW-TEMPERATURE fractional analysis, like laboratory analytical distillation, of which it is a part, is a highly general method, of great scope of application,[1] as regards boiling point range, number of various components determinable, analytical requirements, etc. Thus it is really a large number of methods in one, if it would be properly classified into specific, step-by-step procedures (and suitable apparatus modifications or adjustments), each suitable for a reasonably narrow sample composition and particular analytical requirement: as the Rubber Reserve Committee standardized analysis procedure for butadiene containing cracked C_4 samples.[2] The NGAA is, of course, doing just this, but on a wide range of natural gas and gasoline compositions.

For a very narrow composition range, and for a rigorously standardized apparatus, a highly specific procedure could be written, with fixed sample size, a fixed curve of variable distillate rates vs. amount of distillate, etc. to yield quite closely reproducible distillations and accurate percent results. A relatively untrained operator could be used. Alternatively, the distillate rate could be made constant throughout, at the minimum rate established as necessary for "breaks." This would simplify the procedure greatly and make possible the employment of practically a mental midget operator but with prohibitively long distillation times.

Insofar as analytical procedures fail to meet the above impractical ideals of ultimate specificity, it is necessary to rely on the judgment and skill of analytical pilots trained in the fundamentals of operation of this method, to adapt the variables of operation to the vagaries of sample and safely navigate their particular apparatus into the permissible limits of error. This is still a low price to pay for the flexibility, versatility and power of the method! However, it is important that the analytical pilot be properly briefed on the correct fundamentals, particularly as to most effective column operation, and understanding of the natural limitations of the rather complex distillation process. It is hoped that the discussions to follow will at least outline the applicable theory, data and established practice of separating components in the low-temperature fractionating column.

The design of the analytical apparatus (and its adjustment to the analysis at hand) is inextricably tied up with operating technique and vice-versa. It has always been known, and the results of the NGAA comparative test programs have proven, that within certain limits, good analysts could check closely on many different kinds of apparatus, while the other kind of analysts could produce whopping errors on practically anything. Does this mean apparatus design makes no difference?

The answer, of course, is that a highly qualified analytical athlete can often get acceptably accurate results, even on relatively less effective apparatus, by understanding its limitations, by careful calibrations and corrections, by skillful and intelligent operation individualized for his specific apparatus, by taking more time to make up for low separating power of his column, and spending more labor, if without benefit of automatic control and recording devices. On the other hand, a more efficient column, 75-100 plates, and with other improvements worked out in practice, would undoubtedly greatly decrease the time element, make difficult separations easier, (as iso-butane from n-butane) and would make possible the separation of olefins. Further, analytical athletes of the caliber here pictured are probably vanishing Americans, and in any case, they would be more productive and happier with suitable labor-saving devices.

More pertinent to the present subject is the consideration of apparatus design to preclude and minimize errors inherently, without depending on finicky apparatus calibrations, involved procedures or human element. Obviously, any existing apparatus still has crudities and residual errors, which could be improved when once appreciated, limited only by the ingenuity of the designer. The ultimate would be a completely automatic, continuous push-button affair, having no error and requiring no human element whatsoever. For this occasion, it will probably be more practical to restrict ourselves to the crudities and residual errors of such apparatus as are available at this date.

Errors Due to Human Element

These correspond closely to "pilot errors" so frequently discussed in newsprint, after airplane crashes, where a veteran skilled pilot in a proven, perfectly maintained plane, either forgets his most elementary training, or his mind is distracted from his work by worry or other personal element, or he may get bored and careless, and does the wrong thing at the wrong time.

In our case, the analyst may have lost his interest—perhaps feeling unappreciated or without sufficient opportunity for advancement—or he had a quarrel with his wife or boss, or perhaps, when absent-minded, he just naturally tends to do the wrong thing first. When alerted and on guard, as when running NGAA test samples, such analysts may check beautifully—but in humdrum routine work, they may relax and again turn out reports which will cause St. Thomas, the doubter, to revolve in his grave, with an "I-told-you-so" expression on his face.

Both the cause and the cure of this type of error lie outside of technology and, more properly, within personnel relations, as will be covered by a separate paper of this Seminar. However, the detection of this type of error is definitely a technical problem, and should be routinely and frequently done by means of unlabeled duplicates or synthetics, as is the practice of all properly managed analytical laboratories, regardless of methods used.

There should be no more resentment felt by a worthwhile analyst toward having his work checked in this manner, than by a worthwhile doctor having his surgical technique checked by a consultant.

Errors Due to Apparatus Condition

Here will be discussed errors due to poor adjustment or maintenance of apparatus, or to accidental defects, or to poor choice of accessory sampling and scrubbing units, connections, etc.

A) *Errors that may occur in all apparatus.*

1. **Leaks:** Obviously, highly detrimental to a method which depends on exact measurement of sample volumes. The leak gremlins love to hide themselves in poorly greased and/or poor stopcocks, in wax or rubber connections; they open up pinholes in glass and on-and-off cracks in copper or other metal tubing. Knowing that a large leak is readily detected, the more clever gremlins specialize in insidious slow leaks that may take an hour to show up on the manometer, but are fast enough to take off the accuracy of an analysis like the emery wheel takes the edge off a straight razor!

Leak detection is simple and straightforward. First, the completely evacuated apparatus, with all its sections open to each other, is permitted to stand many hours (preferably overnight) to let even very slow leakage build up detectable pressure on the usual manometer. This procedure can be expedited, down to perhaps 15 minutes, by the use of a McLeod gauge (Figure 1) or other highly sensitive pressure measuring device. If a leak is detected, then the analyst plays a game by opening first one group of sections, then another, to the manometer, finally spotting the offending section and making the necessary corrections.

The design of the apparatus, as the number and type of joints, quality of stopcocks, nature of connections, etc., will naturally have an important bearing on incidence of leaks. Modern practice is to do away with practically all rubber tubing, to use suitable close-clearance adapters on de Khotinsky sealed joints, and premium-grade precision-ground stopcocks, taper and spherical joints. Most commercially available "interchangeable" joints, and most "vacuum tight" stopcocks, are NOT satisfactory for use in low-temperature fractional analysis apparatus.

2. **Obstructions:** While not causing loss of sample, obstructions may affect accuracy in many ways. Grease plugged stopcocks or lines may introduce pressure drops between receiving bottles or column and their connected manometers, causing erroneous pressure readings; may cause lags or surges in automatic recording manometer systems; erratic distillate rates, etc. Kinked metal lines may act similarly. Mercury in connections acts even worse than grease, especially if within brass or other amalgamable metal connections.

The detection of obstructions is not so straightforward as that of leaks. Most obstructions are, however, readily detected by simply checking rates of exacuation or of filling with air, of the various apparatus sections, while preparing apparatus for analysis, and the analyst can usually spot the obstruction without too much difficulty, even during analysis. Stopcock grease, or de Khotinsky cement, can be washed out with acetone. Mercury in column packings may be dissolved out with nitric acid. Kinked tubing must, of course, be replaced.

From a preventive standpoint, the analyst should learn how to grease stopcocks without excess grease, how to make neat wax (de Khotinsky) joints, preferably through use of suitable close-clearance adapters, and watch his mercury levels throughout like a hawk. Since mercury will eventually find a way, it is desirable to replace all brass or copper lines likely to be entered by mercury, with stainless steel.

3) **Contamination:** This may be water remaining in column from wet samples; acetone-grease mixtures; oily

residues of samples, or even vacuum pump oil; residues from previous samples analyzed.

Such contamination is a frequent cause of error, because the vapor pressure of these contaminants is usually too low to be detected by the usual leak tests, and because the usually over-worked oil vacuum pump does not pump out apparatus to below 0.1 or 0.2 mm. Hg. abs. as it should to remove volatile contaminants of this type. Curiously enough, water is particularly difficult to evacuate, as it dissolves vapor pressure lowering impurities and tends to self-refrigerate upon vaporization, thus still further lowering its vapor pressure.

While not removed by pump action, such low-volatility contaminants will be gradually vaporized in contact with sample hydrocarbons, thereby causing definitely appreciable and erratic errors.

The best remedy seems to be a vacuum pump in good condition, which will pump the apparatus down rapidly to about 0.1 mm.; and special care in assuring that this low pressure is actually attained and does not rise slowly, after pumping is discontinued.

Under this heading should probably be included contamination of mercury in manometers, with resulting sticking of mercury, bad electrical contacts, in automatic apparatus, etc. The remedy is obvious. Last, but not least, is the plugging of column packings with oily residues and mercury globules, which can quite completely destroy the distilling capacity and separating effectiveness of any packing. The care required is obvious and methods of cleaning known. Many analysts, however, just don't bother to be vigilant as to condition of column packing, thereby inviting a whole Pandora's Box of troubles and errors.

4) **Sample Absorption:** Like contamination, this is a frequently overlooked cause of error. The most efficient column available operated by highly developed automatic devices, or by the world's best analyst, will not prevent errors up to several percent in magnitude when the receiving bottles are conveniently connected to the column with gracefully festooned coils of many feet of rubber tubing (taken from actual case history!) The large and unequal absorption of hydrocarbons in natural rubber, in Neoprene and in other elastic connecting materials, has been fully determined by many laboratories including the author's. Only the shortest possible connections (preferably with abutting glass or metal tube ends) should be used, and then with Neoprene or certain other low absorption plastic tubing, rather than natural rubber. De

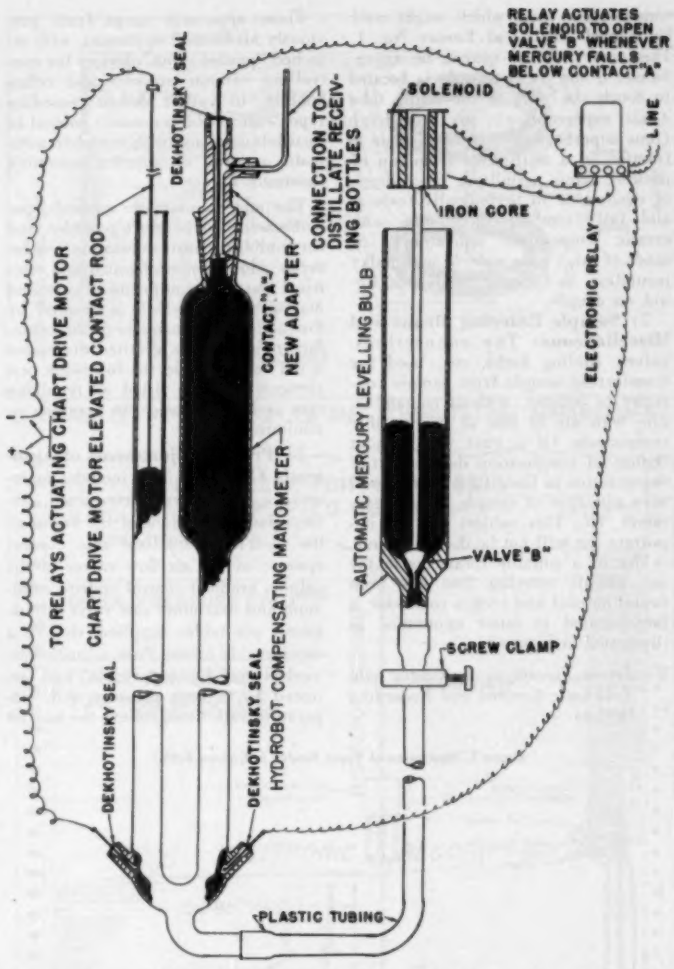


Figure 2. Automatic Mercury Levelling Device for Use with Hyd-Robot Receiver Connected Manometer.

Khotinsky cement seems to have very low absorption and is safe to use. Incidentally, olefins are particularly soluble in rubber, and other elastomers.

Calcium chloride drying material is taboo for olefins, because of high absorption, although apparently acceptable for saturateds, when in small quantity. Barium oxide, Drierite, and sodium hydroxide are acceptable for scrubbing olefins.

5) **Improper Apparatus Calibration:** Obviously, if the volumes used for receiving bottles, or the bore ratios of manometers are incorrect, a corresponding consistent error will be caused in all computed results. Too frequently, not only are the "dead spaces" in column reflux section, above mercury levels in manometers and in stopcock manifolds connections not accurately measured or computed, for use in proper corrections of apparent distillate volume vs. temperature curves, but they are completely ignored, with resulting consistently large errors. This type of error will be discussed in some detail later in this paper.

6) **Thermocouple Location, etc.** As will be discussed later, even with precise adjustment of the right type of thermocouple junction within the reflux section of a column, with respect to relative positions of top of packing, cooling vessel, etc., this still does not exclude a large and variable error, due to wandering uppermost

condensation ring, which might well be termed Analytical Enemy No. 1. This error will, of course, be aggravated: if the thermocouple is located to touch the wall of the reflux tube (thus supercooling); or too high (thus superheating); or more than a fraction of a millimeter from top of packing (thus permitting large drops of condensate to periodically form at and fall from tip of couple, with erratic temperature indication); or made of large gage wire, or with bulky insulation, to increase holdup of liquid on couple.

7) **Sample Entering Means and Miscellaneous:** The connections, valves, cooling baths, etc., used for transferring sample from sample container to column, without contamination with air or loss of condensable components (if a gas) and without change of composition due to partial vaporization in lines (if a liquid) will vary with type of sample, sample container, etc. This subject is very important but will not be discussed here.

Use of a suitable rotameter in the gas sample entering line has been found helpful and such a rotameter is incorporated in latest apparatus, as illustrated in Figure 1.

B) *Errors Specific to Apparatus with Automatic Control and Recording Devices:*

These apparatus range from previously all-manual apparatus, with attached "partial robot" devices for controlling column pressure and reflux cooling, to latest design recording type, with partial automatic control of distillate rate, and with complete automatic control of simpler operating functions, Figure 1.

The added automatic controls, potentiometric temperature recorder, and curve-plotting instrumentation, necessarily add many mechanical and electrical parts, the adjustment care and maintenance of which is covered by instructions and manuals of the manufacturers. While a detailed discussion is not here possible, the following new elements may be listed as requiring care and maintenance, to preclude or minimize error:

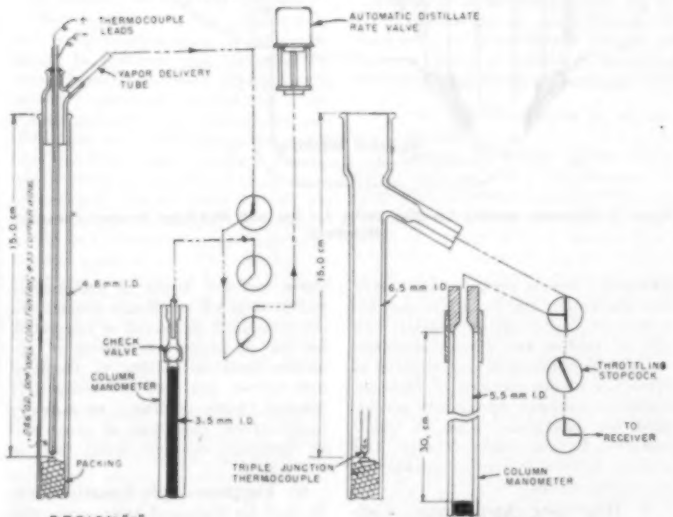
1) **Proper Adjustments of Automatic Controls:** This includes maintenance of designer-determined settings and calibrations of the valves of the hydraulic distillate rate control system; of the air flow valves of the column gradient control system; minimum and maximum rate valve adjustments, per tables supplied, etc. To a considerable extent, these adjustments, worked out by experience, and actuated by column pressure and temperature variations, relieve the analyst from the problems of best general operation, as well as make it possible for him to follow specific procedures closely. While the hydraulic valve and other settings may be changed for special purposes, as to increase speed of analysis, this must be done with understanding of the action of the controls; otherwise, improper settings may quite thoroughly snafu the entire analysis.

2) **Electrical Contacts:** These include contacts "riding" mercury levels in manometers, and relay contacts. It is necessary to have these contacts clean and in good order, also to keep contacting mercury clean and free from surface scum. Failure, or improper action of either the mercury or the relay contacts, causes breakdown of the entire control or recording action, but is, fortunately easy to detect immediately and to correct.

Present practice in apparatus design is to use very low amperage electronic type relays for all mercury-riding contacts and hermetically enclosed standard relays otherwise.

3) **Condition of Control Valves:** These comprise fixed opening hand valves, hydraulically operated shut-off and throttling valves of the bellows powered type, and a number of solenoid operated on-off valves. The usual troubles encountered are corrosion, or breakdown of valve seats, chattering of solenoids, wear of the rate-valve Neoprene tube element, accumulated dirt in the water flow parts, etc. If neglected, such troubles might affect accuracy of analysis in various ways, mostly thru improper distillate rate control. The troubles are usually self-announcing, easily identified, and should be corrected as soon as possible. The analyst should make suitable compensations in his operation of the equipment until the instrument correction can be made: in the worst case, operate semi-manually, as is always possible.

Figure 3. Illustration of Vapor Holdup in Column Reflux.



DESIGN "A"

VAPOR HOLDUP	
REFLUX TUBE	= 1.9 cc
MANOMETER	= 0.2 cc
CONNECTIONS	= 3.0 cc
(100 cm of 2 mm tubing)	
STOPCOCK MANIFOLD	= 0.9 cc
TOTAL HOLDUP	= 6.0 cc

DESIGN "B"

VAPOR HOLDUP	
REFLUX TUBE	= 5.0 cc
MANOMETER	= 8.2 cc
CONNECTIONS	= 3.6 cc
(50 cm of 3 mm tubing)	
STOPCOCK MANIFOLD	= 1.2 cc
TOTAL HOLDUP	= 18.0 cc

Errors Due to Faulty Operating Technique

It is not possible to discuss operating technique in detail without detailed consideration of design of apparatus used. In fact, it would seem especially desirable at this and future similar seminars, to discuss the detailed design, and the as-set-up condition of the various apparatus used by the individual laboratories, with considerable freedom and with liberal constructive criticism.

In the past year, the author and his associates have visited more than 100 laboratories in the Southwest, using low-temperature fractionation analysis. Thus, the present discussion on errors

is based on an unusual opportunity to observe the usually occurring errors.

Some of the errors arise from residual imperfections of even the latest electronic Hydrobot, and Super Cool columns. However, many ancient low-temperature columns are still in use, despite their low separating efficiency and despite many features which seem undesirable now, in the light of more than 20 years' progress in apparatus design. Also, there are many variants of columns and other apparatus components, some of which are perfectly reasonable; while others violate completely the fundamentals of the method. While rigorous standardization of apparatus is neither necessary nor desirable, it seems there should be more of a meeting of the minds as to what constitutes good apparatus design, at least as to the fractionating components proper. Any worthwhile improvements can be incorporated promptly in commercially available apparatus, and can usually also be added to existing equipment.

Skipping over sample entering and apparatus preparation steps, already mentioned, let us consider most frequent errors in:

A) *Collection and Measurement of Distillate:*

While far simpler than control of column conditions, many precautions must be observed to obtain accuracy, as anyone who has tried to prepare synthetic blends from pure gaseous components by manometer pressure rise in evacuated constant volume bottles, should know from painful experience.

1) The bottles must really be of constant volume. Five-gallon water bottles, frequently used, have been shown to contract significantly when evacuated, thus should not be used. Even Pyrex flasks will change volume appreciably, due to temperature changes. There is really no accurate way of correcting by calculation for the effect of large temperature changes of the gas receiving bottles, not even the method of measuring temperature and pressure exactly at each break point. A constant temperature bath of some sort, preferably automatically controlled, is highly desirable.

2) Since a manometer of some sort is used to measure the receiver pressure, the dead space over the mercury and connections to receiver must be added to the receiver volume. Unless the mercury level in the connected manometer arm is kept constant by some continuously leveling device, the variation in this dead space must be considered in calculations. Neglect of these corrections may lead to large errors in the case of large manometer bores and small receivers.

In the Hydrobot, a compensating taper is used to make this correction automatic—but only for the standard one-gallon bottle for which the taper was computed. For larger bottles, or several parallel bottles, the taper may introduce more error than if it were removed, and there is no simple or practical way to correct by calculation.

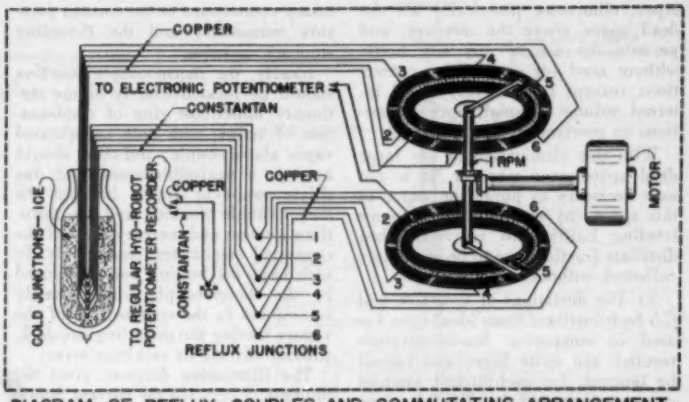


DIAGRAM OF REFLUX COUPLES AND COMMUTATING ARRANGEMENT

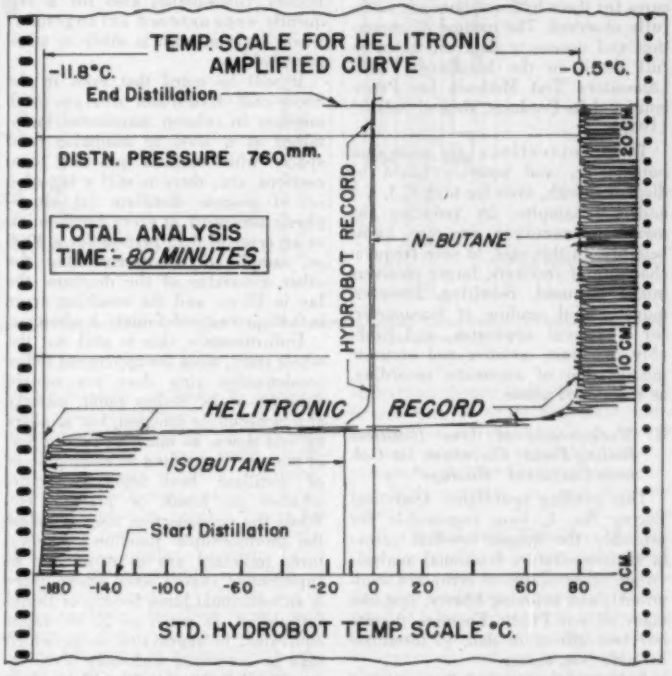


Figure 4 (top). Diagram of Multiple Reflux Thermocouples and Commutating Arrangement, used in Heli-Tronic Device to eliminate error of variable liquid holdup above Thermocouple.

Figure 5 (bottom). "Heli-Tronic" Distillation of Iso-Butane-N-Butane Blend.

However, there are real advantages in using optionally both small receivers, to sharpen breaks on small amounts of components and large receivers for faster and more convenient collection of methane and lighter from large samples of dry natural gas. Accordingly, an automatic mercury leveling device has been worked out in author's laboratory, as per illustrative diagram, Figure 2, which replaces the

taper, eliminates practically all the dead space above the mercury, and permits the use of any size bottle without need for any holdup corrections (except for the very small internal volume of small bore connections to receiver).

With this elimination of the large dead space over mercury, it is not now necessary to purge the vapor in this space (by manipulating mercury leveling bulb) into receiver, when distillate fractions are to be separately collected, without contamination.

3) The deviations of C-3, C-4, and C-5 hydrocarbons from ideal laws (as used in computing low-temperature results) are quite large and cannot be ignored, for such liquid samples as recently tested by NGAA, even when the usual limiting receiver pressures for these hydrocarbons are faithfully observed. The method of correction and necessary data are given in full detail in the handbook "UOP Laboratory Test Methods for Petroleum and Its Products, Method 162-40" (1940).

These corrections are somewhat bothersome, and possibly could be dispensed with, even for high C-3, C-4 and C-5 samples, by reducing the maximum receiver pressure limits suitably. In this case, to save frequent changing of receivers, larger receivers might be used, requiring, however, more careful reading of manometer, for a manual apparatus, and probably the more sensitive and accurate modification of automatic recording, as mentioned above.

B) *Measurement of True Distillate Boiling Point; Correction for Column Connected "Holdups":*

This heading spot-lights Analytical Enemy No. 1, long responsible for probably the largest residual errors in low-temperature fractional analysis (when other causes of error are minimized), and enjoying liberty, just like many of our Public Enemies, despite our best efforts to date to terminate his nefarious career.

It is true that one of the cooperating laboratories has worked out a method of determining very accurate cutpoints by determining vapor pressures (in a separate apparatus) of each cutpoint fraction—but this is somewhat like the government slapping a huge income tax on the otherwise untouched illegal operations of a crime ring. It would be faster and easier to obtain equally accurate cutpoints directly from the distillation curve.

The problem can be understood from the diagram, Figure 3, of column reflux section, thermocouple and necessary connections to the column pressure manometer and the throttling stopcock or valve.

Ideally, the thermocouple junction should be located exactly at the stationary uppermost ring of condensation of reflux, with only superheated vapor above couple; and there should be only a negligible amount of distillate vapor or liquid between the thermocouple junction and the throttling element and mercury level of the connected manometer, respectively. In such case, the boiling point indicated by the thermocouple would exactly correspond to the composition of the vapors leaving the throttling stopcock, without any lag or resulting error.

The illustrative diagram gives the holdups in cc.'s for the current Super-cool column Hvd-Robot (or Semi-Robot) combination also for a frequently encountered arrangement where little attempt is made to minimize holdups.

It will be noted that even in the Super-cool Hvd-Robot design, with mercury in column manometer maintained at a level to minimize dead space, with smallest practical connections, etc., there is still a lag of 6 cc. of gaseous distillate (at atmospheric pressure) at every break-point, or an error of 0.15 percent for a 4000 cc. sample, if uncorrected. For the other apparatus of the diagram, the lag is 18 cc. and the resulting error is 0.45 percent—definitely a whopper.

Unfortunately, this is still not the whole story, since the uppermost reflux condensation ring does not remain constant at its design point, namely at thermocouple junction, but wanders up and down, as much as two inches, or more,[3, 1] depending on boiling point of distillate, heat input to kettle, whether on break or plateau, etc. When the condensation ring is below the thermocouple junction, temperatures indicated are in error due to superheated vapor; when above, there is an additional large holdup of liquid introduced, as much as 20 cc. vapor equivalent in aggravated cases, which may be compared with only 6 cc. vapor in all the connections above thermocouple, as just discussed. The liquid holdup above thermocouple is variable and cannot be entirely corrected by using corrections based on a fixed average value for this holdup.

For the correction or minimization of the above outlined errors, the following are recommended, or suggested for consideration:

a) *Correction for Fixed Holdups.* It is absolutely essential in all analyses to make the simple corrections required, to correct for lags, using computed or measured volumes of the holdup spaces. It is the practice of some laboratories to arbitrarily increase the value of the fixed holdup correction by about 100 percent to at least average out the effect of variable liquid holdup error above the thermocouple. Taken together these corrections will amount to ½ percent or more. There is more than a suspicion that not all the cooperating laboratories of the NGAA program have been making this correction in reporting their results, thereby lowering the percentage of the lowest-boiling component, and raising correspondingly the percentages of the highest boiling components. The detailed corrections were given in another paper at this Seminar.

b) *Low Holdup Thermocouples.* Even a fine wire thermocouple junction of the usual type tends to hold up considerable liquid at its junction and on its necessarily somewhat bulky insulation. It is suggested that a tubular couple, with 0.025-inch o.d., 0.004-inch wall constantan tube, with a No. 33 copper wire, fused to bottom of tube be used instead, with resulting considerable reduction of adherent liquid film, and increased ease in centering, as illustrated in Figure 3. The precautions for installing all thermocouples have already been mentioned above.

c) *Smooth Operation at Minimum Holdup.* The analyst can considerably decrease the absolute as well as variable liquid holdup in reflux section, by controlling heat input to maintain relatively thin reflux films thruout the column, and by minimizing fluctuations in column pressure, reflux cooling, etc. Frequent inspection of the reflux section (if the column has the usual peep-holes) for "fatty films" is highly recommended.

d) *Use of Multiple or Exploring Thermocouples.* During World War II, the author's laboratory made available, at the request of war agencies, a so-called "Helitronic" device, per illustration, Figure 4, which obtained accurate distillate boiling points, through use of cyclically commutated multiple thermocouples, spaced within column reflux section.[3] The typical distillation of isobutane and n-butane blend, Figure 5, shows the significant range of temperatures in reflux section, over about 2 inches length of six spaced thermocouple junctions. Due to its complexity, this device has not found general use. However, it is possible to achieve similar good results through use of an automatically actuated single exploring thermocouple (Figure 6) moving up and down within a hollow core Heli-Grid type packing, to always indicate the lowest and therefore the correct distillate boiling point temperature. The residual variation of

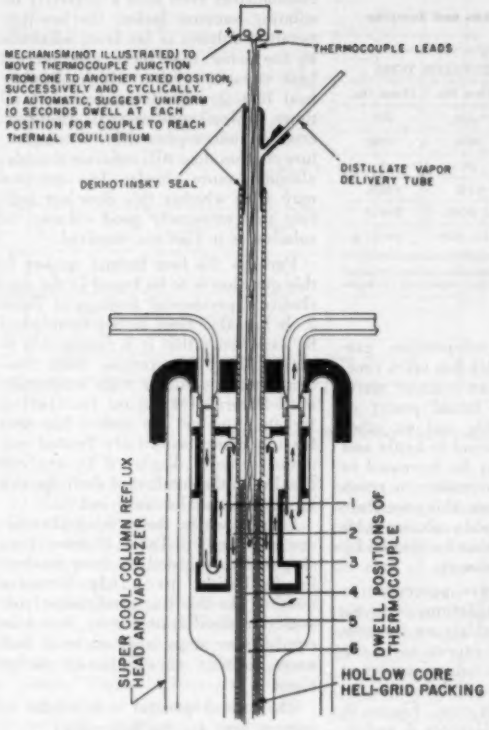

MECHANISM(NOT ILLUSTRATED) TO MOVE THERMOCOUPLE JUNCTION FROM ONE TO ANOTHER FIXED POSITION, SUCCESSIVELY AND CYCLICALLY. IF AUTOMATIC, SUGGEST UNIFORM 10 SECONDS DWELL AT EACH POSITION FOR COUPLE TO REACH THERMAL EQUILIBRIUM
THERMOCOUPLE LEADS
DEXHOTINSKY SEAL
DISTILLATE VAPOR DELIVERY TUBE
SUPER COOL COLUMN REFLUX HEAD AND VAPORIZER
1
2
3
4
5
6
DWELL POSITIONS OF THERMOCOUPLE
HOLLOW CORE HELI-GRID PACKING

Figure 6. Exploring Thermocouple to Follow Uppermost Condensation Ring.

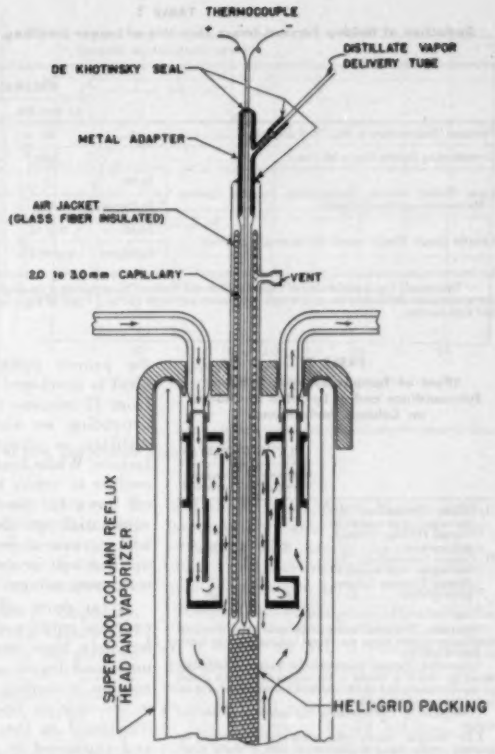


Figure 7. Low Temperature Column Reflux Design to Stabilize Uppermost Condensation Ring.

vapor volume above thermocouple is relatively unimportant.

e) *Stabilization of Condensation Ring by Reflux Design:* The complete practical solution of this particular problem is still not at hand, despite considerable research in author's laboratory; suggestions are humbly solicited. However, the use of a distilling tube with a special reflux section including a jacketed capillary as illustrated in Figure 7 appears very promising in nailing the uppermost condensation ring to the one design point. Difficulties had been experienced with this design in flooding in the capillary, etc., however, it is hoped that further experimentation will overcome the troubles, with the desirable results of both fixing the variable liquid holdup and minimizing the vapor holdup above thermocouple.

f) *Use of Larger Samples and Higher Capacity Distilling Tubes:* A practical solution of the whole problem of errors caused by the holdups discussed, is to use much larger samples, thus lessening the effect of holdup on final percentages. This, in turn, indicates columns of suitably greater distilling capacity, in order to maintain short distillation times, without loss of separating effectiveness. As a matter of fact, the use of very small diameter and capacity columns is a hangover from many years ago, when liquid air was expensive, column liquid air vaporizers inefficient, and transportation of large samples a problem. Table 1 shows the substantial reduction in holdup errors possible with the use of large capacity, distilling tubes, with no serious disadvantages, and with the added advantage of more effective handling of dry natural gas samples. In these larger diameter distilling tubes the reflux portion is unchanged in diameter from the standard 4.7-mm. diameter Heli-Grid packing, thus introduces more liquid holdup in reflux. It is also possible to make the larger diameter column packings more efficient, generally, than packings of minimum diameters, as shown in Figure 8.

C) *Control of Column Operation:*

The batch analytical fractional distillation process that goes on within the slender low-temperature column is quite complex. Some understanding of underlying theory and of best practice is necessary to avoid flagrantly poor separations, and resulting large errors, as well as to use available column equipment to best advantage in securing high accuracy in least analysis time.

1) **Underlying Theory:** The author has tried to construct and present a helpful, integrated theory of low-temperature fractional analysis operation.[4] It is not necessary to understand the theoretical formulae used, in order to appreciate and put to use the conclusions and practical operational guides derived. It is the feel of the thing that counts!

Available theory is helpful in understanding low-temperature fractional analysis, but cannot be a complete guide to actual operation, primarily because theory is based on many assumptions, which are mathematically convenient, but not in accordance with the actual situation. Thus, theory assumes zero column heat capacity and liquid holdup, unchanging concentration gradient, and perfect column adiabaticity. None of these assumptions is true for low-temperature fractional

TABLE 1

Reduction of Holdup Percent Errors Thru Use of Larger Distilling Tubes and Samples

(Same Distillation Times)

		HELI-GRID DISTILLING TUBES		
		4.7 mm. Dia.	8.0 mm. Dia.	13 mm. Dia.
Optimum *Boil-up Rate in Ml./Hr. N-Heptane		30	100	200
Corresponding Sample Size in Ml. Gas		2400	8000	16000
Vapor Holdup between Thermocouple Junction, Column Manometer and Rate Stopcock	In Ml.	8	8	8
	In Percent	0.33%	0.1%	0.05%
Variable Liquid Holdup above Thermocouple Junction	In Ml.	0 to 18	0 to 18	0 to 18
	In Percent	0 to 0.75%	0 to .23%	0 to .11%

* Determined from consideration of Capacity, Plate and Holdup Characteristics of Packings; comparison checked by actual low temperature distillations on same sample, with above size ratios and at 2, 7 and 16 watts heat input, respectively, in supercool type column.

TABLE 2

Effect of Temperature of Column Surroundings and of Location of Charge on Column Performance

	PLATES BY TEST‡	
	Operating "Forward"*	Operating "Inverse"†
I. Column Surroundings "Super-cooled" with respect to Natural ΣColumn Temperature gradient	80	10
II. Column Surroundings "Super-heated" with respect to Natural ΣColumn Temperature gradient	15	100

* Operating "Forward" refers to the usual batch fractional distillation process where the charge is located in the kettle at base of column.

† Operating "Inverse" refers to batch fractional distillation where the charge is located in the condenser of reflux circuit at top of column and the kettle which serves only as a reboiler has very little holdup.

‡ Computed by the Smoker or Equivalent analytical formulae.

Σ By "Natural" column temperature gradient is meant the gradient corresponding to adiabatic or near adiabatic conditions.

analysis, and hence, we must consider the modifying effects on theoretical conclusions of the true situation, in the following specific discussions.

2) **Column Heat Capacity and Holdup Reactions:** The metal packing and the interior glass tubing and other parts of the low-temperature column have of course quite appreciable heat capacity, plus that of the reflux liquid on the packing during column operation. The fractional distillation process is based on a delicately balanced temperature and composition gradient up and down the column, highly specific for each moment of a batch distillation.

Since, at the beginning of a distillation (and after every major disturbance, as at sharp breaks and when changing pressure) the metal and glass internal parts of the column are at various temperatures far removed from the natural initial temperature gradient, the column must be refluxed, without distilling, for a long enough time to cool down—or warm up—properly in all its parts to the proper gradient. In addition the operating liquid holdup of the column must be built-up by internal fractionation, until the proper initial composition gradient is developed. All this takes time, from 15 minutes to an hour or more, depending on what initial purity of distillate is acceptable and on other factors. While heat input to kettle and cooling to reflux may be increased to cut down the time necessary to reach substantial equilibrium, this procedure will increase undesirable column holdup, and will in any case be limited by maximum column capacity.

A far more effective procedure to expedite column distillations is to alternately blow heated air up the column, and liquid air vapors down the column, according to column tendency to increase or reduce its pressure, as illustrated in the diagram, Figure 9, and explained in references 4 and 5. This device, which is quite extensively used in low-temperature fractional analysis, will obviously expedite warming up the column at breaks, instead of waiting for the slow action of kettle heater alone, and without overloading the column. Furthermore, as will be discussed a little later, the accentuation of the "normal adiabatic" column temperature gradient, has an important favorable effect on separation.

Disregard of the need to bring the column close to its proper operating gradients, before taking off distillate, may result in very poor separations, even of methane from ethane, regardless of column effectiveness, and is probably a frequent cause of error. The operation of total refluxing the column to attain equilibrium may advantageously be combined with the "preflooding" procedure necessary with the Heli-Grid, as well as with other high-efficiency column packings, to obtain highest plate number performance. However, it is not necessary, nor usually convenient to effect preflooding earlier than on the ethane or propane plateau.

3) **Column Adiabaticity:—A Sacred Cow!** It should be apparent from the immediately preceding discussion, that even with a perfectly insulating vacuum jacket, the low-temperature column is far from adiabatic in the sense that there are internal heat capacity effects which simulate heat loss through the column, at all times, unless compensated. However, even an uncompensated low-temperature column may still separate sharply, although more slowly. The question may arise whether this does not indicate that extremely good column insulation is in fact not required.

Perhaps the best factual answer to this question is to be found in the conclusive experimental findings of Table 2. It has also been amply established by experience that it is impossible to obtain sharp separations from low-temperature columns with inadequate or deteriorated vacuum insulating jackets. And yet the author has seen far too many beautifully frosted columns, proudly displayed by analysts basking in the comfort of their thereby air-conditioned laboratories!

Until recently, the striking phenomena reported in Table 2[1] have been skeptically regarded by most workers in distillation, probably because nothing like this was predictable from available distillation theory, based on equilibrium steps and material balances, instead of diffusional mechanism.

The useful general conclusions to present here are the following:

a) Reasonable supercooling below the normal adiabatic temperature gradient is favorable to increasing purity of low-boiling component leaving top of low-temperature column, therefore sharpens lower half of "break" in distillation curves; but is unfavorable to stripping out last traces of low-boiler from kettle, therefore worsens right half of "break."

b) Even very slight superheating etc., destroys the separation of the low-boiling component leaving top of column, thus "slops" the lower half of the "break"; has reverse effect on right half of the "break."

The column temperature gradient control device is designed to supercool upper half of column and superheat lower half, thus combining the good effects only of: a) and b) actions. It is instructive to insert thermocouples up and down the column and to test out the correctness of: a) and b) by first cutting out entirely the heated air, then the super-cooled air, and noting effect on column temperature gradient; as has been done in author's laboratory.

The useful corollaries towards practical column operation and apparatus design consideration, are too many to list completely, but following seem

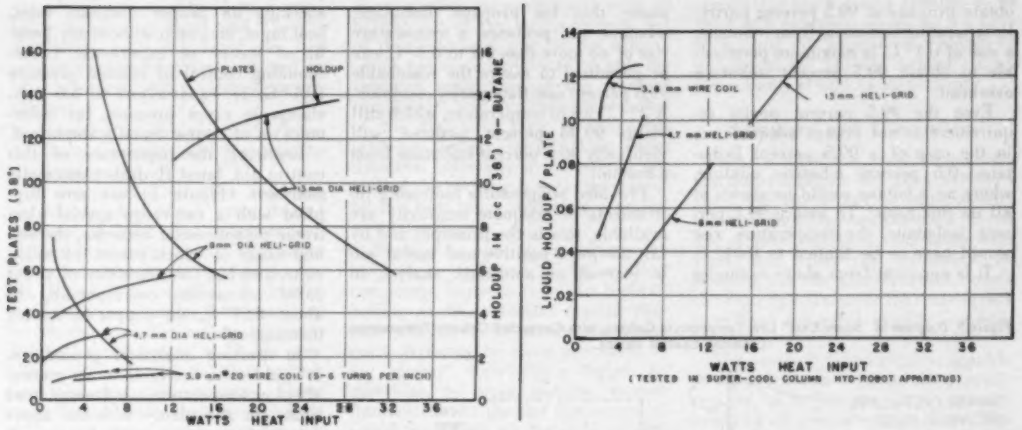


Figure 8. Plate and Holdup Characteristics of Low Temperature Column Packing.

most applicable at this time:

a) Column heat capacity effects, while slowing action of column unduly, if uncompensated, tend to have a favorable effect on separation, especially at breaks.

b) Superheating of column, especially near its top or at reflux is destructive of sharp separation, regardless of normal column effectiveness or "plates." Thus a bad vacuum jacket, or poor design of top detail of column can severely handicap accuracy on close-boiling components.

c) Supercooling of bottom of column, as by too-enthusiastic use of liquid air cooling devices around kettle, may impede the stripping of last traces of low-boiler from kettle contents, resulting in long-drawn out sloppy right half of the "break." On the other hand, too vigorous superheating at this point may dry up downcoming reflux from column packing, resulting in adverse effects on the entire break.

d) Especially on close-boiling components, column temperatures gradient is the result of a surprisingly delicate balance of small interchanges of the separating hydrocarbons and calories, at very small temperature differentials. Therefore as much care should be taken in minimizing column pressure and heat input or reflux cooling fluctuations, as in providing best possible column insulation, if full use is to be made of intrinsic column fractionating effectiveness. To illustrate, when 0.5° C. may represent the difference in boiling point between 100 and 97 percent pure component (isobutane—n-butane) a fluctuation of column pressure of 15 mm. is also equivalent to about 0.5° C. boiling point change and therefore obviously upsetting (if rapid) to the carefully built up composition gradient of the column. It would seem desirable to limit any rapid column pressure fluctuations to within a few millimeters, at least in the case of close-boiling components.

4) **Column Plate, Capacity, Holdup and Operating Characteristics:** The essential data are given in the graphical tabulation of Figure 8, which objectively compares packings of interest in low temperature fractional analysis, including the recently available high-capacity higher-efficiency 8-mm. and 13-mm. Heli-Grid tubes. The plate number determinations were made after preflooding the packings, as is customary for high-efficiency column packings.

The effectiveness of a packing for analytical distillation, where least sample size and least distillation time are desired, for equal accuracy, is quite completely indicated by its "efficiency factor,"[1] which is the boil-up capacity of the packing divided by its holdup per plate. It will be noted that the simple wire coil packings are deficient by this criterion, although adequate for sharp separation of methane, ethane and propane, and butanes. For more difficult separations, as isobutane from n-butane, isopentane from n-pentane, and certainly for any olefin separations the more efficient Heli-Grid packings are more suitable, especially the 8-mm. and 13-mm.-diameter types.

This graphical tabulation should be a useful guide in deciding best heat input values and sample sizes. Since the plate number of all the packings decreases, and the liquid holdup increases, with increasing boil-up rate, or heat input, it is generally accepted that the best point of operation should be at about only 30 percent or less of the floodpoint capacity. While higher heat inputs will permit higher distillate rates at same reflux ratios, this advantage will usually be more than offset by the resultant large increase in holdup; hence larger intermediate fractions and need for larger sample size, hence longer distillation times. As a matter of fact, it will be noted that the larger diameter packings operated at same capacities as the smaller packings, will actually have the same or but little more liquid holdup—an important fact in analysis of dry gas samples for pentanes plus.

5) **Practical Aids in Adjusting Distillate Rates (and Heat Input) During Distillation:** While the foregoing general information should be of considerable help to the analyst in establishing the limits of reflux ratio and distillate rate variation, optimum heat input, etc., something more specific and immediate is needed to guide his hand on the distillate rate stopcock and on the kettle heater rheostat. Fortunately, there are at least three very handy and in fact indispensable aids of this kind:

a) *Distillate Purity Indication from Boiling Point:* Reference should here be made to a special graphic chart, entitled "Relation between Rise from True B. P. of Hydrocarbon and Contamination of its Equilibrium Vapor with Higher Boiling Component," which is available as Figure 2 of reference 4.

The analyst can safely keep boosting his distillate rates, as long as the overhead temperature indicates acceptable purity, by the criteria of this chart: for example, in separating methane from ethane, 99.98 percent pure methane is obtained even with 2° C. rise from B. P. of methane. In separating propane from isobutane, a rise of only 0.3° C. can be permitted to

obtain propane of 99.5 percent purity. In separating isobutane from n-butane, a rise of 0.1° C. is maximum permissible to obtain 99.5 percent isobutane overhead.

Even the 99.5 percent purity requirement is not always adequate, as in the case of a 99.5 percent isobutane—0.5 percent n-butane mixture, where no n-butane would be shown at all on this basis! To assure 99.8 percent isobutane, the temperature rise would have to be limited to 0.04° C.

It is apparent from above examples alone, that for propane, isobutane, n-butane and pentanes, a temperature rise of no more than 0.1 to 0.3° C. can be permitted to assure the reasonable 99.5 percent distillate purity condition. A 2° C. rise in temperature, which still yields 99.98 percent methane, will yield only 90.0 percent isobutane from n-butane!

Provided temperature indicating instruments of adequate sensitivity are available, this is the principal and by far the most positive and useful aid to manual or automatic analyst, in checking on proper distillate rates, heat input, etc., even without any benefit of theory or experience. Corresponding control of column pressure (0.1° C. is equivalent to 3.0 mm. change in vapor pressure, for isobutane) is of course equally important.

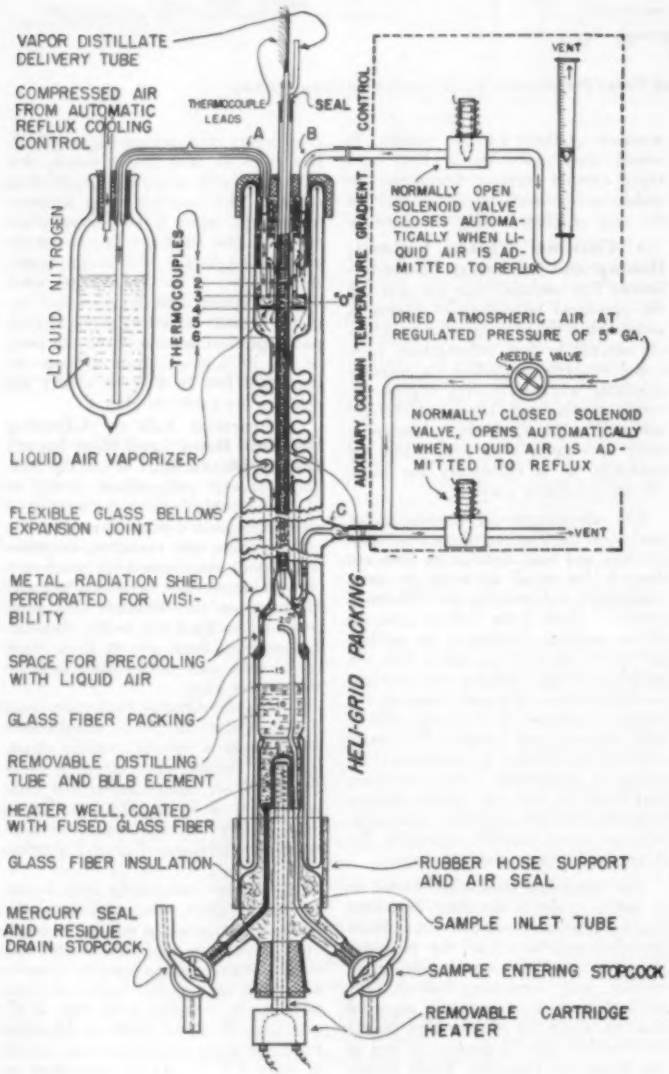
Realizing the importance of this control aid, latest Hydrobot automatic analyzers (Figure 1) are now supplied with a two-range special electronic potentiometer recorder, the second range of which covers 0-2 millivolts, and has the sensitivity of about 0.003 microvolts, corresponding to about 0.07° C. on copper-constantan thermocouple.

In drafting analytical procedures, it would seem desirable to set reasonably low temperature-rise-from-plateau limits, in accordance with the above data and reasoning, with due consideration of course of generally available temperature measuring instruments. Otherwise, it is of course necessary for the analyst to depend on maximum distillate rate figures, derived both from theory and from experience, to maintain the actual distillate purities at desired values, beyond the sensitivity of available temperature measuring instruments.

b) *Spot Total Reflux Test:* In order to establish pure component boiling point, also to give the column an extra push near the breaks and for difficult separations it is very good practice occasionally to shut in the column for a few minutes at a time and observe overhead temperature. If, on a plateau, the temperature does not drop, this means all is well and go ahead; if, however, the temperature does drop more than 0.1° C. or so, this is evidence that the previous distillate rates were too fast for the job. Near the breaks, each such period of total refluxing seems to organize all the little molecules of recalcitrant low-boiler traces, previously overwhelmed by the bulk of ascending next higher-boiler; thereby sharpening the corners of the break portion of the distillation curve. It will be noted that the Hydrobot control devices act similarly.

c) *Column Pressure Sensitivity Indication:* As a break is approached, for constant heat input, it will be found that the tendency of the column to drop pressure after each cooling or withdrawal of distillate will be gradually increased. In fact, at a sharp break, it may take several minutes after each removal of a small amount of distillate for the column to come back to standard pressure. This is, therefore, a very useful indication for both manual and automatic control—all that is necessary is to stop distillation completely whenever column pres-

Figure 9. Diagram of "Super-Cool" Low-Temperature Column, with Connected Column Temperature Gradient Control Device.



sure drops appreciably (1 to 2 mm.) below standard pressure used. Thereby distillation rates too rapid for best column performance are corrected by being averaged with periods of no distillation.

D. *Selection of Sample Size: Proceduces Pentanes—and Heavier Determination:*

In analytical distillation that sample size is ideal which gives desired accuracy in least time, other considerations remaining equal. The larger the sample the longer it takes to distill. Hence it is wasteful of time to provide larger samples than necessary for sharp separation and to minimize difficulties and errors in 1) the sampling and in 2) the distillate collection and measurement steps. These latter have already been discussed, as well as the use of higher capacity distilling tubes to make possible use of larger samples at no time increase. This still leaves open the question as to proper choice of sample size with specific distilling tubes and specific samples, with special reference to effect of column holdup on separation of smallest desired component fraction.

One method of arriving at sample size is to require that the sample be large enough to provide the smallest desired component in quantity equal to the column holdup: thus a gas sample would have to provide about 200 cc. of pentanes-and-heavier vapor to wet completely a 3.8-mm.-diameter 38-inch-long single wire coil packing. The underlying assumption of this method is that it takes all of the column length to make the required separation. This assumption is not far from true in the case of the above packing which has only 10 to 15 plates (reference 1, page 191) or hardly enough to separate n-butane from isopentane. However, the use of this method on Heli-Grid or other high-efficiency packings, testing more than 100 plates[1] for the same length, gives absurdly large sample sizes, since, obviously, only about 4 inches of the more efficient packing would still have as many plates as the simple wire coil packing, and far lower holdup for same distilling capacity. (The "Efficiency Factor," reference 1, page 182, introduced by Bragg and modified by the author makes the proper comparison of packings to take into account boilup rate, holdup and number of plates.)

Therefore it is suggested that the above method be modified to refer to holdup not of the entire column, but of that fractional part of the column which has enough plates to provide the required separation of the smallest component. Actually, only a few inches of the Heli-Grid type packing will separate sharply isopentane from n-butane, especially if the holdup per inch of the packing is well-thinned out by low heat input, and after a period of total-refluxing.

However, a special procedure may have to be followed if the smallest component happens to be the highest-boiling as the important case of pentanes-and-heavier in natural gas. There must obviously be some provision, as by "chaser" high-boiling liquid, or otherwise, to make possible proper fractionation of the last few inches of liquid travelling up the column like the tail end of a slow freight.

The author's laboratory has tested and in fact at one time recommended the use of "chasers"; however, this expedient has been accompanied by difficulties and not entirely successful. The time-honored and commonsense trick of filling up the holdup of kettle with mercury at end of distillation seems to be satisfactory and in fact indispensable, unless sample sizes and distillate times are to be increased many times. The objections to liquid being caught between mercury and kettle walls can be completely overcome by gradual admission of warm mercury, while a substantial amount of condensate still remains in kettle, by stopping distillation and cooling strongly to drive all liquid onto packing, then entering mercury into the temporarily dry bulb, etc.

However, it does seem essential towards end of distillation when column packing is only partly wet to provide a suitable externally enforced temperature gradient, as by the column temperature gradient control device, Figure 9, preferably using air heated above atmospheric temperature to vaporize the oily highest-boiling traces from the upper kettle and lower column regions, where even warm mercury is not effective. The external gradient is necessary because there no longer is a source of vapor from kettle to provide usual fractionating gradient, and because a simple vaporization of liquid from packing, without temperature gradient provides little if any separation; a very important point. Therefore, it would seem desirable for much larger samples to be used with columns, which do not have some sort of provision, manual or automatic, for blowing heated air up the column at end of distillation.

Summary and Conclusions

The method of low-temperature fractional analysis has been reviewed from the standpoint of emphasizing those underlying fundamentals which are of most practical interest to analysts, and from the standpoint of pointing out the most frequent causes of error. Specific cures for these errors have been suggested insofar as possible.

The method is inherently capable of accuracies, as well as of a precision, of 0.1 to 0.2 percent, if properly used and all precautions observed. The capability of the method for reduced total distillation times has not all been fully exploited, but Starr, Anderson and Davidson[6] have demonstrated high accuracy within as little as 1½ hours, using available apparatus types. Proper training of analysts in fundamentals of operating technique, with the assistance of specific analytical procedures where applicable, should make it possible for most laboratories to approach the accuracies and short times just stated.

Arbitrary rigid standardization of apparatus would stop progress; however, there should be more general understanding as to what constitutes good apparatus design and adjustment, and the necessary interdependence of specific apparatus design and specific operating technique.

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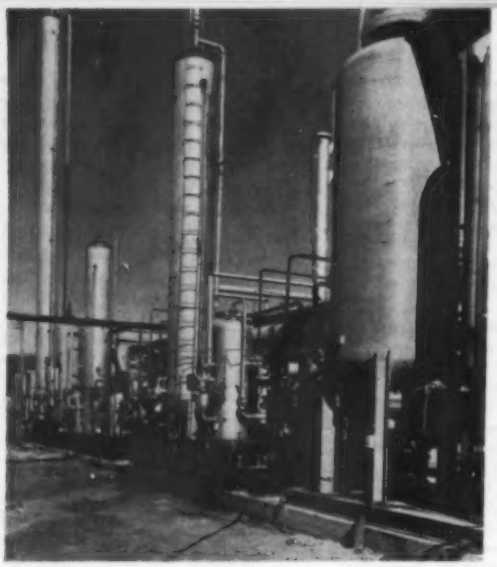


FIGURE 1

Gladewater Adds Perco Reforming Unit

H. A. GREBE, A. L. MILES, and K. W. SEED

GLADEWATER Refining Company, Gladewater, Texas, recently placed in operation a Perco Cycloversion unit as part of its modernization program to meet higher octane requirements. This unit, designed and constructed by Grebe and Doremus Process Company of Houston, is built to process 650 barrels per stream day of either cracked gasoline or straight-run naphtha or blends of the two. Installation of the utility lines such as cooling water, steam, gas and electrical leads was made by the regular maintenance crew of Gladewater Refining Company.

The complete unit is mounted on three skids with the exception of the three direct-fired heaters; namely, the process heater, the steam superheater and the debutanizer reboiler. The shop-fabricated assembly was shipped from Houston to Gladewater where a concrete pad approximately 40 feet long and 8 feet wide had been prepared as a foundation. There are actually four skids on this pad, three of which are for the Perco unit. On the fourth skid is mounted a stabilizer for thermally cracked gasoline, which operates apart from the Perco unit proper and in connection with the thermal cracking and catalytic polymerization units. **Figure 1** shows the completed unit as described above. The unit was shipped as shown with the exception of the fractionator and debutanizer columns which were not erected until the skids were set on the concrete pad. These columns were insulated, however, before leaving the shops.

The skids contain the following equipment:

Skid No. 1 **(Fig. 3, left foreground):** 1) Two catalyst chambers; 2) Valve manifolding for chamber switching during processing and catalyst regeneration; 3) Finned tube heat exchangers (which provide heat exchange between catalyst chamber effluent and process heater feed);

Skid No. 2 **(Figure 2):** 1) Charge pump; 2) Fractionator; 3) Fractionator overhead condenser; 4) Fractionator reflux accumulator; 5) Fractionator reflux pump (which also furnishes charge to the debutanizer surge drum); 6) Rotary air compressor;

Skid No. 3: 1) Debutanizer feed surge drum, into which is fed straight run naphtha from the topping unit as well as Perco fractionator accumulator liquid; 2) Debutanizer feed pump; 3) Debutanizer; 4) Debutanizer reflux drum and pump; 5) Debutanizer reboiler circulation pump; 6) Debutanizer overhead condenser.

Figure 2 shows a close up view of Skid No. 2 which contains the fractionator and accessories. Also in this picture can be seen a portion of the stabilizer for thermally cracked gasoline.

Figure 3, in the left foreground, shows

A NEW skid-mounted Perco unit at Gladewater Refining Company permits a small refinery to remain octane competitive. The cat poly unit now under construction will handle olefinic gases from the Perco unit and thermal cracker and will produce high-octane blending component.

Of the authors, Mr. Grebe is with Grebe & Doremus Process Company, Houston; Mr. Miles is with Gladewater Refining Company, Gladewater and Mr. Seed is with Perco Division, Phillips Petroleum Company, Bartlesville, Okla.

TABLE 1
Catalytic Desulfurization of Thermal Cracked Gasoline

	Charge, Raw Cracked Gasoline	Product, Unstabilized Caustic Washed Desulfurized Gasoline
Operating Conditions:		
Space Velocity, Vol./Vol./Hr.		1.23
Catalyst Case Inlet Temp., F.		785
Catalyst Case Pressure, psig.		44
Catalyst		Cyclocel Grade Bauxite
Product Inspection:		
Gravity, API at 60° F.	57.5	58.2
ASTM Distillation, F.:		
IBP	104	100
10 percent evaporated	156	160
30 percent	226	226
50 percent	277	267
70 percent	320	310
90 percent	370	363
E. P.	415	402
Recovery, vol. percent	98.0	98.0
RVP, psi.	7.0	7.2
Total Sulfur	0.058	0.020
Mercaptan Sulfur, wt. percent	0.016	<0.001
Bromine No.	68	83
Research Octane Numbers:		
Clear	63.5	67.0
+1 ml TEL/gal.	72.8	76.8
+3 ml TEL/gal.	79.4	83.6

Skid No. 1 on which the two catalyst chambers are mounted. In the right background can be seen from left to right the debutanizer reboiler, the steam superheater and the process heater. Though installed apart from the skids, the heaters are so situated that the entire area required by the Perco unit, including the control room and the thermal stabilizer, is about 30 by 100 feet.

The control room will include instrumentation required by the catalytic polymerization unit, which is designed to handle the olefinic gases produced from the operation of the Perco unit and the thermal cracker. California Research Corporation's film-type catalytic polymerization unit is now being added to the facilities at the plant and the absorber and stabilizer columns for this unit can be seen in the background in **Figures 1 and 2.**

The initial operation of the unit was on a cracked gasoline charge, which was processed at desulfurization temperatures only. Table 1 shows operating data and inspection tests on charge and product.

The data of Table 1 shows a 48.4 percent removal of total sulfur and a 94 percent removal of mercaptan sulfur with a 4.2 octane number increase at the 3-cc.-TEL level.

Table 2 shows operating data and inspection tests on charge and product when processing a 170°-475° F. straight-run naphtha. The fractionator overhead is shown as the final product. Fractionator bottoms constitute about 1 percent of the charge to the unit.

The first run listed in Table 2 represents very mild reforming of the naphtha at 940° F. This low reforming temperature was sufficient, however, to give a Research octane increase of 8.2 numbers at the 3.0-cc.-TEL level. More indicative of the reforming operation which Gladewater will probably employ in meeting their finished gasoline specifications is Run No. 2. In this run at 982° F. chamber inlet temperature, the Perco product rated 78.4 Research octane (3 cc TEL per gallon). The product quality demanded will determine the severity of catalytic reforming, which can be varied over a wide range. Butanization of the above products to finished vapor pressure, as shown at the bottom of Table 2, considerably improves the octane ratings.

The greatly improved marketing position attained by Gladewater Refining Company through its Perco unit and catalytic polymerization unit will undoubtedly solve production problems for octane requirements for years to come. Perco catalytic reforming and desulfurization, due to the inherent flexibility of the process, again offer a solution for the small refinery in meeting octane specifications.

TABLE 2
Catalytic Reforming of Straight Run Naphtha

	Perco Charge	FRACTIONATOR OVERHEAD PRODUCT		
		Run No. 1	Run No. 2	Run No. 3
Operating Conditions:				
Space Velocity, Vol/Vol/Hr.		1.06	1.01	0.99
Catalyst Case Inlet Temp. °F.		940	982	1015
Catalyst Case Pressure, psig.		47	50	50
Catalyst		Cyclocel Grade Bauxite	Cyclocel Grade Bauxite	Cyclocel Grade Bauxite
Product Inspection:				
Gravity, API @ 60 °F.	51.4	54.0	53.5	53.2
ASTM Distillation, °F.:				
IBP	170	124	109	117
10 percent evaporated	257	229	212	210
30 percent	286	268	252	254
50 percent	310	287	276	267
70 percent	345	313	306	309
90 percent	412	357	349	353
E.P.	475	404	409	427
Recovery, vol. percent	97.0	98.0	98.5	98.0
C_5+ gasoline, vol. percent of charge	100.0	93.8	90.4	83.5
RVP, psi. @ 100 °F.	1.0	4.1	6.2	4.5
Total Sulfur, wt. percent	0.013	0.006	0.006	.....
Mercaptan Sulfur, wt. percent	<0.001	<0.001	<0.001	<0.001
Bromine number	11	16	.....	.....
Research Octane Numbers:				
Clear	41.5	53.3	60.0	65.3
Plus 1 ml. TEL/gal.	51.7	64.0	69.5	74.0
Plus 3 ml. TEL/gal.	67.0	75.2	78.4	81.5
Calculated:				
Yield, Butanized gasol. vol. percent of charge	100.0	102.4	98.1	90.9
RVP psi. @ 100 °F.	1.0	9.0	9.0	9.0
Research Octane Numbers:				
Clear	41.5	57.3	62.0	68.0
Plus 1 ml. TEL/gal.	51.7	67.5	70.9	76.6
Plus 3 ml. TEL/gal.	67.0	77.9	79.9	83.6

FIGURE 2

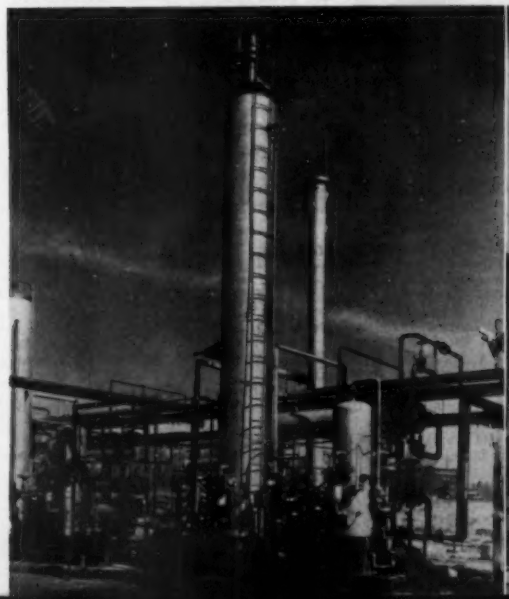
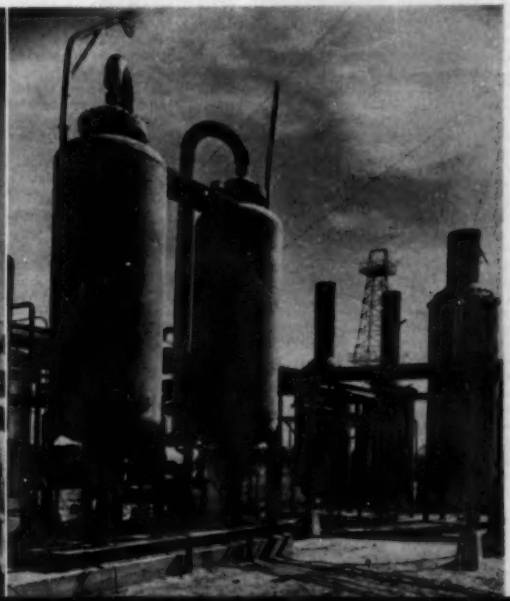


FIGURE 3



REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the industry.

Effinger

Wilson

Renquist

Wachter

Baker

Kerns

Shell Quartet Deals With Steel Corrosion

R. T. EFFINGER, member of the quartet which wrote "Hydrogen Attack of Steel in Refinery Equipment," appearing on page 132, is a senior engineer at Shell Oil Company's Martinez, Calif., plant. He was first employed by Shell in 1935 as laboratory inspector at the Martinez refinery. After graduation in 1939 he rejoined Shell as plant technologist, serving in that capacity until 1942 when he was promoted to corrosion engineer in the same plant. During the 1942-1949 period he concentrated on corrosion, both from metallurgical and environmental points of view. Effinger holds a B.S. in Chemistry from the University of Washington.

Joseph G. Wilson, also of Shell Oil Company, New York, received his B.S. in mechanical engineering in 1932 from the University of Michigan. He first joined Shell in Mexico at the Minatitlan refinery and then in 1935 moved to the Tampico refinery. He engaged in engineering, maintenance, and construction. Transferring to the Shell Development Company as head of the mechanical engineering section, he busied himself with the research and development of processes for the manufacture of petroleum and chemical products. He currently is assistant manager of the manufacturing-engineering department of Shell Oil Company.

Dr. Melvin L. Renquist, Shell's representative on the process group for the special committee on hydrogen attack of steel, is well acquainted with design problems of new plants and revisions to existing plants and is particularly interested in fractionation. In fact he played a major part in the development work which led to Shell's commercial production of cyclohexane and benzene from petroleum at its Wilmington plant. Dr. Renquist has been a member of the Shell organization since 1942 when he entered as a technologist in the San Francisco research and development department.

Dr. A. Wachter, fourth member of the quartet, was a national research fellow from the University of California from 1930 to 1932 and engaged in research on the thermodynamic properties of solid solutions of salts and of metals. He joined Shell in 1932 to engage in research on chemical petroleum processes. As head of the corrosion department since 1938, he has concentrated his efforts on corrosion prevention in all phases of petroleum and related chemical operations.

Deep Sea Fishing Keeps Him Contented

"COOLING Equipment Performance" which starts on page 110, was written by Harold A. Dresser, a full fledged author with articles in various magazines to his credit and no stranger to the printed page.

Dresser

Dresser, district sales manager for The Marley Company, Inc., is an alumnus of California Institute of Technology, Pasadena; a member of the State Board for Civil and Professional Engineers; a member of the Natural Gas Association of America and a member of the Board of Directors of that organization. Since 1926 he has been associated with the Dri Cooling Industry.

A native and resident of Los Angeles, he finds himself in an ideal spot for pursuing his favorite hobbies; close to salt water for deep sea fishing trips, and with the length and breadth of the continent to roam when he gets a yen for a long travel jaunt. Dresser is married and happily mentions his lovely 20-year-old daughter as a fundamental part of his biographical information.

Sohio Authors Discuss Aluminum in Refining

"USE of Aluminum in Refinery Equipment" an article found on page 123 of this issue is the product of E. E. Kerns and William E. Baker, both of The Standard Oil Company (Ohio).

Kerns, born in Fairfield County, Ohio, attended Capital University and Carnegie Tech, receiving a mechanical engineering degree from the latter in 1925. He did inspection work for Standard Oil Company (New Jersey) for three years and then joined the Louisiana Oil Refining Corporation at Shreveport as a member of the process unit testing. He was promoted to mechanical superintendent of its Bossier City refinery and served in that capacity until 1934, when he transferred his services to The Standard Oil Company (Ohio). At present he is in charge of the materials and equipment section of general engineering.

Baker is a 1943 graduate of the University of Cincinnati and holds a degree in chemical engineering. Prior to service in the Navy he did production and maintenance work for Calco Chemical Division of American Cyanamid Corporation. Upon discharge from the Navy he joined The Standard Oil Company (Ohio) and has been employed in the general engineering division since that time.

Chem Engineers Write Of Research Study

"A METHOD of Estimating the Pour Points of Blends of Petroleum Distillate Stocks" on page 93 of this issue is the work of two California Research Corporation members, Eugene B. Reid and Howard I. Allen.

Reid was born in Chico, Calif., and studied at Chico State College for two years before transferring to the Univer-

CORRECT SPECIFICATION

is part of the picture

Revere Admiralty Metal Tubes in a heat exchanger fabricated by the Nooter Corporation, St. Louis, Mo.

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Among the Revere Condenser Tube Alloys are: Admiralty Metal, Arsenical Copper, Muntz Metal, Aluminum Brass, Aluminum Bronze, Cupro-Nickel. Revere also supplies tube plates in a variety of alloys. If you have any questions regarding the selection of tubes or plates for condensers and heat exchangers, consult Revere.

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Reid

Allen

sity of California where he received a B.S. in Chemistry in 1935. After a brief period with the Shell Development Company, he continued his academic work at the University of Michigan and received a Ph.D. in 1939. Until he joined the Coast Artillery for service in the Aleutians (later he saw service with the Chemical Corps at Army Chemical Center, Md., and at Dugway Proving Ground), he was a member of the staff of the Research and Development Department, Standard of California.

After the war Reid returned to this firm, now reorganized and known as California Research Corporation, and was assigned to the Refinery Technology and Technical Service division.

A college track athlete at the University of California, he still participates in many refinery athletic activities.

Allen, co-author of the article, is a chemical engineer and 1942 graduate of the Illinois Institute of Technology. After four years with the U.S. Navy he joined the California Research Corporation and has worked in the process design, refinery technology and technical service groups.

Tate Writes Of Heating Development

C. C. TATE, manager of the Refining Department for Phillips Petroleum Company, is the author of "A New Development in Radiant Heating for the Petroleum Industry," which appears on page 103. Tate, whose headquarters are in Bartlesville, Okla., started to work for Phillips in 1932 after receiving a B.S. degree in Electrical and Mechanical Engineering from Kansas State College.

Tate

His varied experience in refining operations includes 12 years at the Borger, Texas, and Okmulgee, Okla., refineries. Living in Mexico was one of the advantages—or disadvantages—of a three-year period from 1945 to 1948 when he served as special Phillips representative of the Petroleos Mexicanos project. He returned to Bartlesville in 1949 to become manager of the Refining department.

Podbielniak Honored for Lab Apparatus Research

Dr. Walter J. Podbielniak, president of Podbielniak, Inc., of Chicago, was honored during the recent meeting of the Natural Gasoline Association in Tulsa, when he was presented with the Hanlon Award, the highest honor in the natural gasoline industry.

He received the award in recognition of the part he has played in the early development of practical analytical apparatus and for his continuous effort to improve accuracy and efficiency of such instruments. The low temperature fractional analysis equipment familiarly known as the "Pod column" is a piece of standard equipment in most oil company plants and laboratories.

Dr. Podbielniak began the manufacture of low temperature analytical equipment in 1929 after a brief period engaged in research for Phillips Petroleum Company.

Dr. Podbielniak is author of the article on page 145 of this issue. Part I of his "Precise Fractional Distillation Analysis" appeared in the April issue of PETROLEUM REFINER.

Frank N. Porter Named VP World Petroleum Congress

Frank M. Porter, president of the American Petroleum Institute, has been named the American vice president of the Third World Petroleum Congress to be held at The Hague, Netherlands, May 28 to June 6.

Porter was named vice president and member of the Committee of Honour by the organizing committee. W. Alton Jones, president of Cities Service Company and chairman of the board of API will serve with Porter as representatives of the American petroleum industry.

The U. S. government will be represented by Gen. E. O. Thompson, member of the Texas Railroad Commission and Dr. W. E. Wrather, director of the U. S. Geological Survey. Dr. E. V. Murphree, Standard Oil Development Company, is chairman of the national committe for the U. S. and members of his committee are: F. S. Clulow, Shell Oil Company; Dr. Paul D. Foote, Gulf Research and Development Company; H. R. Tate, Standard Oil Development Company; and Mrs. Luther D. Swanstrom of Master Reporting Company.

President of the Congress is Jonkheer O. C. A. van Lidth de Jeude. Five vice presidents were appointed from the chairmen of national associations of petroleum technologists: Prof. P. Erculisse, Belgium; R. Navarre, France; C. A. P. Southwell, Great Britain; Prof. M. Boldrini, Italy; Frank M. Porter, United States, and Dr. Gustavo Thery-Fombona, Venezuela.

McKenna Is Safety Director

Jack McKenna has been named safety director of Lion Oil Company, El Dorado, Ark. He served as assistant safety director since 1948 although lately he has been acting safety director.

Employed as a boiler maker helper in 1933, McKenna has 18 years of uninterrupted service with Lion Oil Company to his credit. In 1943 he was named refinery safety engineer.

Ex-Teacher Tells Of Technical Classrooms

AUTHOR of "Technical Classrooms on the Job," on page 77, is H. Dayton Wilde, Humble's manager of research and development. Dr. Wilde, born in Aguascalientes, Mexico, at the turn of the century, received his B.S. and M.S. from the University of Texas, and a Ph.D. from MIT. He has taught at both schools. His doctor's thesis was a study of plate efficiency in commercial petroleum fractionating towers and involved a practical research period with Humble.

Wilde

In 1927, Dr. Wilde was employed by Humble in the technical and research division at its Baytown refinery, and in 1929 was transferred to Houston to head a new group for carrying on research for the production department. Although continuing as manager of production research he became, in 1933, manager of the technical and research division of the refining department. He held this responsibility until 1945 when he was promoted to manager of research and development for the company as a whole, inclusive of the research done in geophysics and production.

Dr. Wilde is a member of ACS, AIMME, AICE, and API and was for a time active in the AIMME Petroleum Division as a member of its board. He is currently a member of the Aircraft Fuels Committee of the Military Petroleum Advisory Board and is director of the AICE.

Refinery Veteran Retires After 44 Years of Service

After almost 44 years of continuous service with The Texas Company, R. G. Collins, 34 years a refinery official and lately superintendent of West Dallas Works, has retired. He began working for The Texas Company in 1907 at Henrietta, Okla., on the Tulsa-Port Arthur pipe line.

His various jobs have included still fireman and in 1910 he started the Texaco stills at Tulsa; inspector in charge of laboratory and shipments at Tulsa; and assistant superintendent of the same plant. His assignments have led him to Tampa, Fla., Shreveport, La., Amarillo and Dallas. Collins will remain in Dallas.

Sinclair Promotes Allen

C. J. Allen has been promoted to assistant to the president of Sinclair Oil Corporation but will continue as vice president of Sinclair Refining Company. L. M. Fuller, who has been with Sinclair Refining since 1922, has been elected assistant treasurer of Sinclair Oil Corporation, succeeding Allen.

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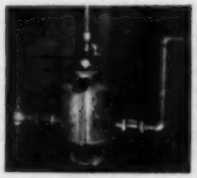

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The MONTH... in the INDUSTRY

Superfractionating columns at Abadan refinery, a plant spotlighted by recent news developments.

Iran Nationalizes Oil Without Settling Terms

Seizure of the $500 million Abadan refinery pictured above was effected early this month when the Shah of Iran signed an act nationalizing the British owned Anglo-Iranian Oil Company property. British and American envoys were unable to keep negotiations open to maintain the contract granted the company in 1933 under free negotiations for a period of 60 years. Abadan, "the world's largest refinery," was taken without mention of compensation or terms of surrender.

Earlier, British officials had hinted they would appeal to the United Nations for intervention. Anglo-Iranian Oil Company had been operating under handicap of flare-up strikes the past two months in addition to threats of governmental action. The company, which was winding up its expansion and modernization program, charged local agitators had stirred the workers to "revolt."

After a five-year program a new catalytic cracker and gas recovery plant having an approximate capacity of 8000 barrels-a-day, is nearing completion. The project was undertaken to improve the balance of white and black oils produced by the refinery. Forty percent of the 400,000 barrels of crude processed daily was proposed for motor or aviation gas.

Approximately 50 percent of the cat cracker output was scheduled for processing as fuel gas, butane/butene (for use in the alkylation process) and gasoline for use as motor or aviation gas. The cat cracker was designed by Foster Wheeler Corporation.

PAD Invites Industry to Plan World Oil Expansion

Troubled by the threat of a strike shutdown at Anglo-Iranian's Abadan refinery in Iran the past two months, PAD initiated a round of discussions with industry on the question of how industry might be permitted to organize to take up world slack in oil production. PAD estimated that if Abadan was completely shutdown the United States might be called upon to supply 200 to 275 thousand barrels-a-day above present production.

Result was an understanding between the oil industry and PAD that the industry might negotiate voluntary agreements which would carry immunity from prosecution under antitrust laws because the Justice Department had insisted on placing a government official as chairman of each industrial committee.

Although the strike dwindled away in April, late news from Iran indicates that any plans PAD might have formulated will be put into action. Reorganization of the Iran government has removed pro-western sentiment from governing circles and will possibly mean that Iranian oil is lost to the free world.

The possibility of stepping up foreign refineries to maximum capacity as a means of increasing accessible petroleum was examined by PAD and on the face appeared to be a possible solution as many refineries at present operate on allocations far below their maximum capacities.

Time to Pioneer Synthetic Fuels, Chapman Declares

Opposite opinions regarding need for synthetic fuels was expressed last month by Interior Secretary Chapman who championed development of the synthetics plan, and Eugene Holman, president of Standard Oil Company (New Jersey), who declared that the industry has been so successful in finding new sources of oil that synthetic fuel will not be necessary in the foreseeable future.

Chapman said that one or two commercial shale and coal plants built now would pioner future large-scale production of liquid fuels. In addition, he said, chemicals produced by the coal plants would make a noteworthy contribution to our defense program.

Phillips Election Names Endacott as President

Paul Endacott has been elected president of Phillips Petroleum Company to succeed K. S. Adams who was elected chairman of the board and chief executive officer as well as chairman of the executive committee.

Stanley Learned was elected executive vice president and assistant to the president. W. W. Keeler, formerly vice president of refining, was elected a director, and vice president and assistant to the executive vice president. C. C. Tate was appointed manager of the refining department and J. E. Bogk was appointed chairman of the operating committee.

One-Fourth Smog Condition Blamed on Oil Industries

Latest report by Stanford Research Institute lays 25 percent of the smog responsibility to the petroleum industry "because it is by far the largest industrial user of fuel." Another 15 percent of the cause is laid to other industries. A preliminary report issued in February blamed the general public for 60 percent of the air pollution. The new report commented that diversity of source of responsibility of smog proved that it is a community problem and can be abated only by community action. The Western Oil and Gas Association sponsors the smog investigation.

Dr. Paul Foote Honored

Dr. Paul D. Foote, Gulf Oil Corporation vice president in charge of research and development, received the outstanding achievement medal award of the University of Minnesota at Minneapolis during the University's centennial observances. The honor is reserved for former students who have attained high eminence and distinction.

Foote

Member of the Ordnance Advisory Committee of the Research and Development Division, Department of the Army and a member of the Naval Ordnance Laboratory Advisory Board, he was during World War II a consultant to both the office of Scientific Research and Development and to the Research and Development Board.

Author of notable scientific papers, he is associate editor of the Journal of the Franklin Institute and active in many scientific and petroleum organizations.

Lynch Elected by NGAA

John F. Lynch, La Gloria Corporation, Corpus Christi, has been elected president of the Natural Gasoline Association of America. He succeeds James E. Pew, Sun Oil Company, Philadelphia.

Treasury Fires on Co-ops; Advises Revised Tax Plan

The Treasury Department has handed the House Ways and Means Committee a lengthy study advising Congress it may legally impose full corporate income taxes on co-op net earnings. The

USE AIR *instead of liquids* FOR COOLING

While the principle of air-cooling in heat exchangers is not new, its adaptation on a large scale in industry is being recognized more and more. Air as a coolant can be used under certain conditions with greater economy and higher efficiency than is practical with liquids.

The advantages of air-cooling are readily recognized in cases where ample water supply is not available, where such water may cause scale or premature corrosion, or where treatment required for the water would prove expensive. Many more advantages will suggest themselves.

One of the major components in all air-cooled heat exchangers is, of course, the tubing. And the tubing that deserves serious consideration in such applications naturally is Wolverine Trufin* (the integral finned tube)—and specifically the bi-metal Trufin. This tube has aluminum fins and copper liner, which latter can be supplied in most copper base alloy specified to accommodate the contacting fluids. Obviously, such factors as corrosion, pressure, etc. determine the type of liner and composition of the tube that would prove most efficient.

Since the fins of Trufin are integral with the outer tube itself, they stand upright and remain in a fixed position. Moreover, because there is a good mechanical bond between the two metals, very little loss of efficiency is experienced regardless of the type of liner.

There is much specialized experience here at Wolverine upon which you are invited to draw for help in solving problems involving heat exchangers.

Shown here are two views of an air-cooled heat exchanger installed in the south by Hudson Engineering Co. Nearly a quarter-million square feet of surface area is represented in the installation of Wolverine Trufin—the integral finned tube. This bi-metal Trufin was specifically developed for this air-cooling application and is the direct result of the study of conditions found there by Wolverine's Customer Engineering Service.

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study was prepared in conjunction with House-Senate committees on Internal Revenue Taxation, and attacks "patronage dividend agreement between a co-operative and its members since the parties to such an agreement are not dealing at arm's length as is the case in an ordinary rebate."

The report pointed out that congress has treated co-operatives as corporations, since in exempting certain farm co-operatives from tax, it has exempted them from the corporate tax. Past cases prove, according to the report, that congress could repeal present corporate income taxes and replace them with excise taxes which could be measured by the "net margins of the corporation, regardless of whether or not these margins represented income."

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1950:									
January 28	4,986	5,470	248,411	18,363	124,270	7,302	66,337	8,389	37,086
February 25	5,000	5,277	245,586	17,703	133,888	6,890	56,056	7,855	48,663
March 25	4,948	5,469	244,227	17,839	135,406	6,870	40,577	8,171	42,546
April 29	5,014	5,314	244,744	18,038	128,655	6,531	36,686	7,272	39,260
May 27	5,118	5,591	240,942	18,704	122,757	7,201	40,607	7,421	39,308
June 24	5,355	5,636	240,762	19,626	115,036	6,868	50,580	7,461	41,291
July 29	5,522	5,870	240,236	19,981	109,076	7,266	61,437	7,870	42,253
August 26	5,699	6,197	236,934	20,263	105,793	7,559	65,841	8,543	41,697
September 30	5,903	6,051	241,631	19,624	104,383	8,460	76,734	8,306	42,330
October 28	5,895	6,051	244,805	19,878	105,062	8,250	84,057	8,449	44,310
November 25	5,888	6,236	244,497	19,847	105,424	8,591	85,768	8,470	45,586
December 23	5,763	6,150	250,799	20,075	112,631	9,436	72,273	8,715	39,914
1951:									
January 27	6,066	6,483	244,230	21,106	126,261	9,954	58,997	9,905	40,378
February 24	5,954	6,524	237,204	20,815	138,870	10,545	48,764	9,471	38,995
March 31	6,041	6,381	235,956	20,398	142,186	9,365	43,170	9,147	37,282
April 28	6,154	6,236	239,190*	19,876	137,474	8,061	42,859	8,747	36,080

* April 21 Stocks.

Oberfell Given Appreciation Award By API Refining Division at Tulsa

The sixteenth mid-year meeting of the American Petroleum Institute's Division of Refining was held in Tulsa April 30 through May 3. The meeting included sessions on analytical research, refinery waste water treatment, corrosion problems, electrical equipment, training, motor fuel utilization, and the use of LPG as a motor fuel. Meetings on the principal refinery division committees were held. Attendance exceeded 800.

Dr. Frances Lamb's presentation of "Formation of Engine-Deposit Compounds by Solid-State Reactions," marked the first appearance of a woman scientist before the Refining Division. (See Look Box, page 75.)

At the dinner held Wednesday, May 2, the Division of Refining awarded a "Certificate of Appreciation" to G. G. Oberfell for his services to the API in the fields of automotive research and conservation of natural resources.

Oberfell

Oberfell is the sixth recipient of this award, joining such names as Thomas G. Delbridge, Kenneth G. Mackenzie, Walter Samans, Robert E. Wilson, and Wilson Bregy Hart.

Oberfell, special consultant to the RFC on the synthetic-rubber program, retired last July as vice president of research and development for Phillips Petroleum Company. He established the research and development department for Phillips in 1925. Oberfell has also been a director of the company, a member of the executive committee, and a vice president and director of Phillips Chemical Company and vice president of Phillips Terminal Company.

He spent four years as a junior chemist with the U.S. Bureau of Mines, and a year with Ohio Fuel Supply Company in Columbus, as a chemist. During World War I Oberfell served in the Chemical Warfare Service. Following his discharge he joined Chestnut and Smith Corporation, Tulsa, as research engineer, and later changed to consulting natural gasoline engineer with Seeley-Oberfell Corporation.

A member of the ACS, ASTM, API, SAE, AICE, and AIC, he has also published several papers, made frequent contributions to trade journals and technical publications, and holds several U.S. patents.

Samans, also holder of an API award of appreciation, attended the conference before sailing for The Hague, Holland, where he will deliver a paper on "Unfired Pressure Vessels for the Petroleum Industry" at a meeting of the Third World Petroleum Congress.

Industrial research firms today are giving more attention than ever to their own private training programs for equipping technical men to work more effectively, according to a recent survey of 100 firms by the Industrial Research Institute, Inc. Results of the survey were made public in a talk "Industry Practices in Training Technical Personnel" by H. G. Vesper and D. H. Etzler of California Research Corporation, San Francisco. The study revealed enthusiastic interest in employe training, they said, although only 20 percent of the companies surveyed conducted formal training programs.

Remarks made by H. Dayton Wilde, describing how Humble Oil & Refining Company, Houston, provides technical training for refining research men and technologists, may be read in full on page 77.

Use of liquefied petroleum gas as a motor fuel highlighted the closing session of the midyear meeting. Eugene S. Corner, Standard Oil Development Company and E. H. Berg, Esso Standard Oil Company, reported that an ever increasing number of busses and trucks are being operated on LPG and that as an engine fuel it has the characteristic of being high in octane number permitting use in engines of high compression rates.

At a press conference held during the Tulsa meeting, W. L. Stewart, Jr., executive vice president of Union Oil Company of California, told of a new process for improving quality of products from heavy Santa Maria, California, crude oil. The new process, "Hydrodesulfurization," is being drawn up for full scale commercial installation. The process, he said, is catalytic in nature and combines hydrogenation and desulfurization reactions. Stewart described the gasoline yielded as "marketable."

Osher Goldsmith to Direct Fuel Price Stabilization

Appointment of Osher Goldsmith, Tyler, Texas, as director of fuels and chemicals division in the Southwest Regional Office of price stabilization was announced by Alfred L. Seelye, Dallas regional OPS director. Goldsmith has served as consultant since the opening of the regional OPS office last January 29.

Goldsmith

He will supervise administration of price regulations in the petroleum, chemicals, export and import, ice, rubber, solid fuels and transportation industries. He held a similar position in the Dallas office during the last war.

Goldsmith is a registered petroleum engineer and holds a degree in mining engineering from the Missouri School of Mines, 1920. He has been employed by both major and independent oil companies in all phases of oil business and was at one time an independent oil producer and consulting petroleum engineer with offices in Tyler.

Dr. Charles Allen Thomas Named Monsanto President

Dr. Charles Allen Thomas has been elected president of Monsanto Chemical Company. He succeeds William M. Rand who was first elected president of the company in 1945.

Dr. Thomas was identified with the production of the atomic bomb and is co-author of a plan for control of

Six reasons why the major steel companies are using McKee Engineering Services

MEMO TO

Petroleum Refiners

● This advertisement is published here to acquaint oil men with what the McKee Iron and Steel Plant Division is doing to alleviate steel shortages.

In addition to its refinery engineering projects McKee now has in progress seven blast furnaces, two integrated steel plants, two 750,000-ton open-hearth shops and miscellaneous related projects.

1 Arthur G. McKee & Company have been recognized since 1905 as a leading engineering firm engaged in the design, engineering and construction of iron and steel plants.

2 McKee experience includes all types of iron and steel production facilities from preparation of raw materials to finished steel.

3 The McKee organization has the scope and resources to undertake any steel plant project regardless of size or location. Completion dates of new projects are contingent on present schedules.

4 McKe
edge
completion

5 McKe
blast
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6 Men in the Iron and Steel Industry know from long experience that the McKee method of coordinated engineering reduces plant costs and speeds completion—that ***McKee Engineering means Assured Results.*** That's why they buy McKee Engineering.

DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

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Arthur G. McKee & Company • Established 1905

Headquarters: McKee Building, 2300 Chester Avenue, Cleveland 1, Ohio. *New York:* 30 Rockefeller Plaza, New York 20, N.Y. *Tulsa:* 918 First National Bank Building, Tulsa 3, Okla. *England:* The Iron and Steel Division of Arthur G. McKee & Company, is represented by Head, Wrightson & Co., Ltd.

Starring in **LOW-COST** ...at Sun Oil's

Another Example of Efficient Power at Lower Cost

RIGHT: Pumps are direct-driven through fire wall by these efficient Cooper-Bessemer GMX gas engines. Engine speed, 400 rpm or less, accurately controls pump volume without affecting operating pressures.

ABOVE: One of two 6-cylinder Cooper-Bessemer Twin-Line pumps handling lean oil for methanizing and high pressure absorbing at Sun Oil's Starr County Gasoline Plant.

TWIN LINE Liquid Pumps

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Calif. Houston, Dallas, Greggton.

DOUBLE DUTY

Starr County Gasoline Plant

● Maybe you can pick up a money-saving idea from this unusual pumping operation. Here, Sun Oil wisely took advantage of the flexibility of Cooper-Bessemer Twin-Line pumps to deliver lean oil at two different pressures simultaneously . . . for methanizing and for high pressure absorbing.

Because Twin-Line pumps have two banks of opposed cylinders, because they permit extreme flexibility and hold high efficiencies despite wide variations in demand, they are performing this double service with exceptional economy.

The pump shown opposite is one of two now in Sun Oil's service. The high pressure side of each delivers 248 gpm at 1100 psi. The low pressure side, or first stage, has a capacity of 388 gpm at 225 psi, the excess going to the low pressure demethanizer. Each pump is direct-driven by a Cooper-Bessemer GMX gas engine at 400 rpm, or less, eliminating all need for gearing. Volumes are accurately controlled by varying engine speeds without affecting the operating pressures.

With prolonged 92% mechanical efficiencies and 96% volumetric efficiencies, these units are maintaining operating economy seldom equalled.

The extreme flexibility and simplified drive, of Cooper-Bessemer Twin-Line pumps make them suitable for a broad range of services. Maybe they can save *you* important money. Simply check with the nearest Cooper-Bessemer office.

by Cooper-Bessemer

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

Pampa and Odessa, Texas Seattle, Wash. Tulsa Shreveport St. Louis Los Angeles Caracas, Venezuela

The MONTH...

nuclear weapons. In 1923 he began his industrial career with General Motors as a research chemist aiding in the development of ethyl gasoline; he later established research laboratories in Dayton, Ohio. When Monsanto acquired the laboratories in 1936, Dr. Thomas became Monsanto research director and since 1947 he has been an executive vice president.

National Research Adds Two More Staff Members

National Research Corporation announced that Gordon Kiddoo will serve on the NRC staff as assistant director of the Petrochemical Research Department and that Dr. Manson Benedict, professor of chemical engineering at Massachusetts Institute of Technology, will serve as scientific director.

Kiddoo

Kiddoo was director of Research and Development for Continental Carbon Company at Amarillo, Texas, prior to his appointment with NRC. He received his degree in chemical engineering from Cornell University in 1942 and subsequently was employed by the Chicago Corporation of Corpus Christi, Texas; Hydrocarbon Research, Inc., at its Olean, New York, laboratory, and by The Texas Company. He will be responsible for the engineering economics aspects of the Petrochemical research program which NRC is undertaking jointly with Electric Bond and Share Company and United Gas Corporation.

Dr. Walker, former consultant to the Atomic Energy Commission, will place particular emphasis on the new petrochemical research program in his capacity as scientific director.

Oil Industry Makes Good Safety Gains During '50

The petroleum industry in 1950 achieved the best safety record of its history, according to API's annual survey.

The study shows that the chances of an oil employe being injured fatally or permanently disabled now are about 5900 to one, against an average of 4400 to one in 1949 and 2800 to one in 1946. The number of employes fatally injured or permanently disabled during 1950 was 81, a 26 percent improvement over the 109 reported for 1949.

The past year was the fifth consecutive year in which a decrease in accident frequency and severity was recorded, and the second in which the record bettered the previous lows established in prewar years. During the war, injury rates increased disproportionately because of the shortage of skilled manpower and the constantly increasing tempo of production and output.

The greatest improvement in safety performance last year was among refinery workers. There, the severity rate (the number of days lost per 1000 hours worked) was more than cut in half, dropping from 1.22 to 0.60. The number of workers fatally injured or permanently disabled fell from 42 in 1949 to 15 in 1950. The refinery survey covered 147,990 workers, the largest single group included in the study.

Bureau Says Oil Demand To Increase 8.5 Percent

Oil demands in 1951 will exceed those of 1950 by about 8.5 percent according to the Bureau of Mines which reported that first quarter demand may have exceeded 7.7 million barrels-a-day, or 13.5 percent above the corresponding period last year.

Actual production of domestic crude averaged 5930 million barrels in February and probably averaged 6040 million barrels-a-day in March. The Bureau anticipates that April figures may average about 6130 million barrels-a-day.

THE OIL MAN'S CALENDAR

MAY	
7–11	National Fire Protection Association, Annual, Detroit, Hotel Statler.
13–16	American Institute of Chemical Engineers, Regional, Kansas City, Mo., Hotel Muehlebach.
21–24	Oil Industry Information Committee, Denver, Brown Palace Hotel.
26	John Zink Process Heating Seminar, John Zink Company, 4401 South Peoria Avenue, Tulsa.
28–29	American Petroleum Institute, Mid-year for Division of Marketing, Cincinnati, Ohio.
28 June 1	American Petroleum Institute, Standardization and Standing Committee, Division of Production, Midyear, Denver, Brown Palace Hotel.
28 to June 6	Third World Petroleum Congress, The Hague-Scheveningen, Netherlands.
JUNE	
3– 8	Society of Automotive Engineers, Summer, French Lick, Ind. French Lick Springs Hotel.
7– 8	American Management Association General Management Conference, New York, Waldorf-Astoria.
11–15	American Society of Mechanical Engineers, Semi-Annual, Toronto, Royal York Hotel.
14–15	Pennsylvania Grade Crude Oil Association, Annual Meeting, Pittsburgh, Hotel William Penn.
18–22	American Society for Testing Materials, Annual Meeting, Atlantic City, N. J.
JULY	
9–21	Summer Laboratory Course, "Techniques and Applications of the Electron Microscope," Laboratory of Electron Microscopy, Rockefeller Hall, Cornell University, Ithaca, N. Y.
SEPT.	
3– 7	American Chemical Society, Annual, N.Y. Hotel Statler. 120th National Diamond Jubilee.
10–14	Instrument Society of America, Sixth National Instrument Conference and Exhibit, Houston, Sam Houston Coliseum.
11–13	International Discussion on Postwar Heat Transfer Development with ASME Administrative Coordinator, London.
12–14	National Petroleum Association, Atlantic City, N. J., Hotel Traymore.
16–19	American Institute of Chemical Engineers, Regional Meeting, French Lick, Ind. and Rochester, N. Y., Sheraton Hotel.
25–28	American Society of Mechanical Engineers, Fall, Minneapolis, Minn., Hotel Radisson.
OCT.	
14–20	Oil Progress Week.
15–18	American Gas Association, St. Louis.
NOV.	
5– 8	American Petroleum Institute, Annual Convention, Chicago, Stevens Hotel.

Staid and Gunter Head Carter Oil Manufacturing

Gunter

Staid

Irving J. Staid, Billings, Mont., has been named manager of The Carter Oil Company's manufacturing department and Herman G. Gunter named assistant manager.

Staid, originally from Peabody, Mass., graduated from the University of Alabama in 1938 with a degree in chemical and metallurgical engineering. Before joining Carter in 1945 as chief engineer of the Billings refinery, he was employed as a chemist in the Esso Standard Oil Company refinery at Everett, Mass.

Gunter was graduated in engineering from Johns Hopkins University and was employed by the Jersey Standard organization in 1930 as an analyst in the chemistry laboratory of the Baltimore refinery. He joined Carter in 1947 when the new Billings plant was under construction and since its completion has been general superintendent in charge of operations.

Sinclair Opens Laboratory To Independent Inventors

Independent inventors who are researching, developing and proving out ideas for better petroleum products have been offered use of facilities at Sinclair Research Laboratories, Harvey, Ill., according to P. C. Spencer, Sinclair president.

Inventors wishing to use the facilities will submit their patented ideas to the laboratories' board of directors, and the board will select the projects they feel show most promise, the number being determined by available capacity at the time. In return Sinclair will receive the privilege of using the inventions free of royalties, Spencer said. The inventor is free to market his product in any way that does not infringe on the company's right to use the invention.

Octane Ratings Lowered By TEL Shortages

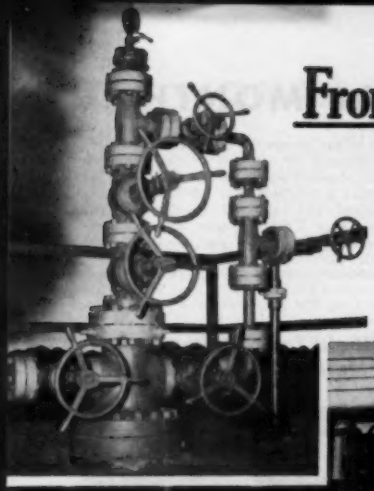
Motor Gasoline Survey conducted every four months by Du Pont indicated that by the first week in April strain due to tetraethyl lead shortages were reflected in octane ratings in certain cities, although other areas actually show an increase over January ratings.

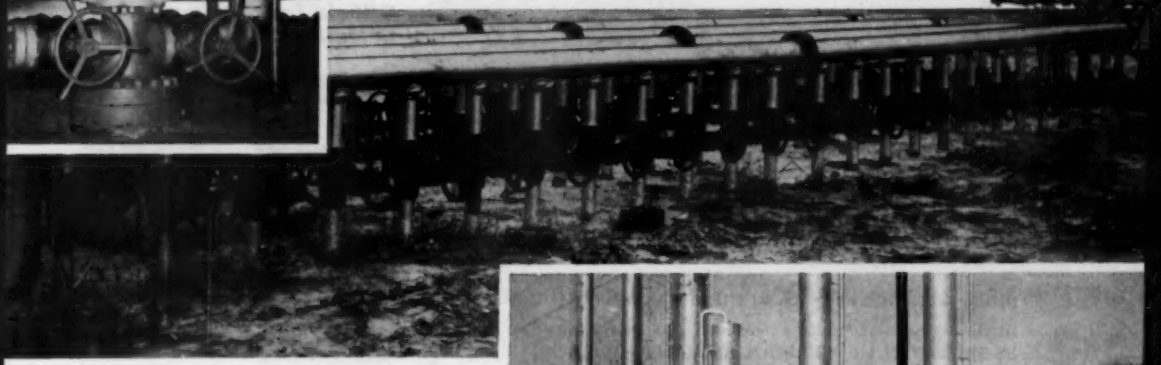
Tabulations show that octane ratings for premium gasoline dropped slightly in 26 test areas, increased in 19 others. Similarly, ratings for regular gas dropped in 30 cities but still showed an increase in twelve others.

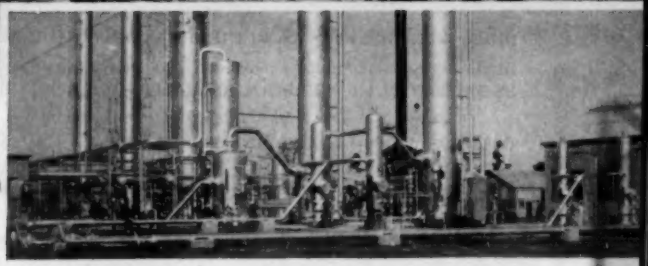
The number of cities showing an octane rating of 90 or above for premium gasoline last January was decreased by

From Well to the L. P. Gas and Cycling Industries

ORBIT VALVES®







FORGED STEEL

Orbit Forged Steel Valves are Dependable. The Orbit principle of valve closure makes it possible to utilize a resilient Body Seat. All *Orbit Body Seats* are deflected in the closed position a sufficient amount to assure a seal, regardless of minor body deflections or normal wear of the seating surface. Contraction, expansion and vibration will not cause the seating surfaces to separate in the closed position.

Use Orbit Forged Steel Production Valves in your Well Head installations.

Use Orbit Forged Steel L.P. Gas Valves in your L.P. Gas plant.

BRANCHES

HOUSTON, TEXAS—407 Velasco
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A SHORT STATEMENT ON

STEAM TRAPS

THAT IS LONG ON GOOD SENSE:

A Steam Trap has but *one* function—to drain condensate from steam lines. Right?

Now if one brand of Steam Trap can drain *twice* as much condensate $ $ = $ under equal conditions, as another of the same size and price—it's just plain common sense to buy that brand, isn't it?

Clark DUO-STEP LEVERAGE STEAM TRAPS have proved in tests time and time again that they *can* drain *twice* the condensate of ordinary traps.

So—do as thousands of smart steam engineers have done:

SWITCH TO CLARK DUO-STEP STEAM TRAPS FOR DOUBLE DRAINAGE EFFICIENCY!

THE CLARK MANUFACTURING COMPANY
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Clark
THE HOME OF DUO STEP LEVERAGE

The complete line of dependable fluid controls

The MONTH...

two in the present test, 28 cities still reporting the 90 or better rating. Sixteen cities showed an 85 or better rating for regular gas which was the same as announced in January. Further results show that TEL content has been increased in five cities and lowered in 30, while thirteen cities showed increased content of regular gasoline while 31 had lowered TEL content. These figures are based on Du Pont research in 48 cities.

Oilfield Tank Makers In National Organization

Zachariae

Lineberry

A representative group of oilfield tank manufacturers met recently in Tulsa and organized the Oilfield Tank Manufacturer's association. The avowed purpose of the association is to promote the common interests of its members, with particular reference to steel allocation, work through and with the American Petroleum Institute towards standardization of products and the gathering and dissemination of statistical data on quantity and kinds of products sold by the industry. Also, the association will assist the National defense program.

Offices have been established in the Tri State Insurance Building, Tulsa, with E. H. Zachariae secretary and managing officer.

Officers and members of the executive committee include: Kenneth W. Lineberry, president of Black, Sivalls & Bryson, Inc., Kansas City; A. Sidney Knowles, president of Parkersburg Rig and Reel Company, Parkersburg, W. Va.; Sam P. Wallace, president of Maloney-Crawford Tank & Manufacturing Company, Tulsa; I. W. Lovelady, president, Sivalls Tanks, Inc., Odessa, and Cecil G. Wells, vice president of National Tank Company, Tulsa.

Elliott Named Nominee

Lloyd W. Elliott, president of Standard-Vacuum Oil Company since 1946, has been designated as a nominee for election to the board of directors of Standard Oil Company (New Jersey).

Petroleum Radio Group To Hold Annual Meeting

The annual meeting of Region 4, National Petroleum Radio Frequency Coordinating Association will be held at the Lamar Hotel, Houston, May 25 and 26. New officers will be elected and members will vote on a plan to be submitted to the Federal Communications Commission for sharing petroleum radio frequencies with the National Forest Industries Communications. All voting

The MONTH...

members are urged by Chairman G. F. McReynolds, Humble Oil & Refining Company, Houston, to attend.

District Region 4 comprises Texas, Louisiana, Arkansas and Mississippi.

Deep Rock Oil Promotes Seuren to Lube Supervisor

William R. Seuren, formerly assistant to W. J. Carthaus, vice president in charge of Deep Rock Oil Corporation's manufacturing and research division, has been named supervisor of lubricating oil finishing at the company's Cushing, Okla., refinery. Donald T. Axon will fill the position vacated by Seuren.

Jefferson Announces Three New Vice Presidents

William H. Bowman, Max Neuhaus, and L. P. Scoville have been elected

Scoville

Neuhaus

vice presidents of Jefferson Chemical Company, Inc., a subsidiary of The Texas Company and American Cyanamid Company. Scoville and Dr. Neuhaus have been with the company since its inception in 1944.

Bowman

Dr. Neuhaus, first manager of the Technical and Research Department, had previously been with The Texas Company and Texaco Development Corporation since 1932.

Scoville joined the new Jefferson Company as chief engineer and later was promoted to manager of the Production Department. Previously he had served with The Texas Company.

Dr. Bowman became Jefferson Market Development manager in 1945 but was named Sales Department manager when that department was organized.

Beman to Head Chemical Products for Socony

Warren A. Beman, staff member in charge of textile work for the chemical products division of Socony-Vacuum Oil Company, Inc., last month was appointed to direct chemical products development for the company.

A primary function of Socony-Vacuums' new activity will be to coordinate the company's development program on all chemical products by working closely

Keep your eye on V-P-I
WHEN SELECTING
BLOWERS

Type OI Centrifugal Blower in southwestern refinery. Capacity 13,000 cfm.

You can't afford to risk shutdowns today because of unsatisfactory or inadequate equipment performance. To keep production moving at the required fast pace, calls for blowers or gas pumps that continuously deliver positive Volume at required Pressure—and at Low power costs to reduce operating expense.

You get these 3 essentials from R-C Blowers and Gas Pumps. Whether your needs call for Centrifugal or Rotary Positive units, we can match them from our exclusive *dual-ability line.* With capacities from 5 cfm to 100,000 cfm, you can usually find R-C units that closely fit your demands, with resultant savings in time, cost, space, weight and power.

From an experience of almost a century of blower building, our engineers will gladly make suggestions of the right R-C equipment to move or measure gas and air to keep production going.

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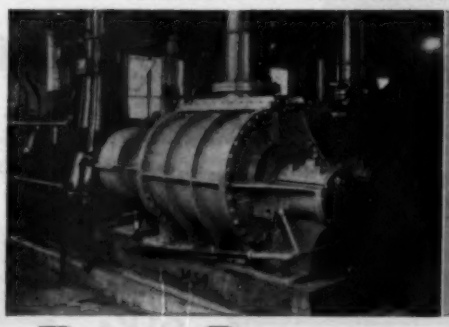
510 Crescent Avenue, Connersville, Indiana



Rotary Positive Gas Pump for handling refinery gas. Capacity 3,100 cfm.

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ONE OF THE DRESSER INDUSTRIES

5 Quality Products for the Petroleum Industry

SOLVAY

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SODA ASH

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CAUSTIC POTASH

(Liquid, Solid and Flake)

CALCIUM CHLORIDE

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Soda Ash · Caustic Soda · Caustic Potash · Nytron · Calcium Chloride · Chlorine · Potassium Carbonate · Sodium Bicarbonate · Formaldehyde · Specialty Cleansers · Ammonium Bicarbonate · Sodium Nitrite · Para-dichlorobenzene · Ortho-dichlorobenzene · Monochlorobenzene · Ammonium Chloride · Methanol

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The MONTH...

with the research and development heads of other leading companies.

A chemical engineering graduate of Purdue University in 1940, Beman also attended the graduate school of the Polytechnic Institute of Brooklyn. Previous to being transferred to New York, he worked in refinery engineering, the development section of Socony-Vacuum Laboratories and in field technical sales and services.

Fowler Joins Midwest Research Institute Staff

Dr. Frank C. Fowler, formerly of the University of Oklahoma faculty, has been added to the staff of Midwest Research Institute, Kansas City, as petroleum consultant. He will conduct investigations in petroleum and allied fields for the Institute. This activity has been initiated as a result of numerous industrial requests for assistance according to Dr. M. H. Thornton, Institute chemistry division chairman.

Fowler

For the last five years Dr. Fowler has administered both graduate and undergraduate courses and directed graduate research at the University of Oklahoma. Prior to that he was employed three years as senior process engineer at Phillips Petroleum Company, Bartlesville, Okla.

Andrew Kalitinsky Heads Kellogg Special Projects

Andrew Kalitinsky, former chief engineer of the Nuclear Energy for Propulsion of Aircraft Project, has been appointed as manager of The M. W. Kellogg Company's special projects department. This department is engaged in research and development of rockets and rocket motors for the U. S. Armed Forces.

Kalitinsky

One of the youngest men ever to receive the honor, Kalitinsky was awarded the Manly Memorial Medal in 1949 by the Society of Automotive Engineers for his paper, "Atomic Power and Aircraft Propulsion."

Kalitinsky was educated in Zurich, later joined the staff of the Massachusetts Institute of Technology, and has worked with Pratt & Whitney Aircraft and Fairchild Engine and Aircraft Company. At present he is a consultant to the U. S. Airforce.

Military Term Contracts Necessary to Expansion

PAD official, Thomas L. Apjohn, last month advocated three to five-year military contracts for petroleum prod-

The best fire-fighting foam is Air Foam!

FREE AIR FOAM REFERENCE CATALOG

Air Foam is more effective, less expensive than chemical foam

Pyrene* Air Foam is the finest fire protection yet devised for oil fire hazards. It extinguishes fast, prevents flash-backs and re-ignition, is *compact* and extremely flexible. Pyrene* Air Foam is available in America's most complete line of portable, fixed, and mobile units, for any size hazard. In most instances, they can be operated by one man! Installation and upkeep costs are almost always lower than those for chemical foam. And foam compound costs less.

If your firm must cope with the danger of oil fire hazards, you owe it to yourself to study the Pyrene reference catalog, and have the information in it available at your fingertips. Send for your copy today—without any obligation, of course.

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MAIL COUPON TODAY! It will bring a valuable FREE reference booklet illustrating and describing air foam equipment for every type of oil fire hazard.

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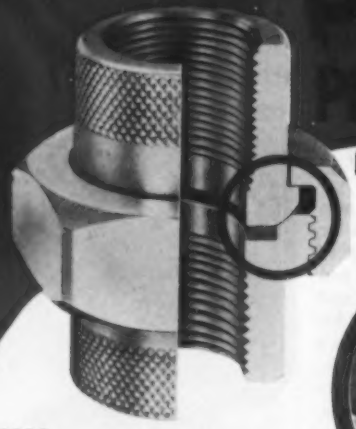

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Seal

Weco "Junior" unions give you a plus value for extra long service and repeated make-up and break-out without danger of leaks. It's the replaceable gasket which protects the famous Weco ball-and-cone seal from corrosive or abrasive action of line fluids and gases. It prevents the possibility of turbulence in the space between the sub ends. With this protection the ball-and-cone ... tion retain ... leak-proof far ... ciation. The gasket ... from virtually all standard gasket materials, thus the Weco "Junior" is applicable for a wide range of services.

The Weco "Junior" has heavy acme threads for faster, easier starting . . . easy break-out. They will not seize. The walls of the sub-ends are heavier and stronger than usually found in unions of this type.

Weco "Juniors" are 3000 lb. non-shock, C.W.P. unions, available in sizes ⅛" through 2" with machine finish or Weco-lyte Cadmium Plated.

OTHER PLUS FEATURES

Weco "Junior" Unions are packed in cartons of 12 (1¼" and larger) and 24 (1" and smaller). This added feature protects the union . . . makes them easier to stock . . . simplifies inventorying.

ASK YOUR INDUSTRIAL, MILL SUPPLY OR OIL FIELD SUPPLY STORE FOR WECO "JUNIOR" UNIONS BY THE CARTON.

WELL EQUIPMENT MFG. CORP.
Subsidiary of Chiksan Company
HOUSTON 1, TEXAS
Exclusive Sales Representative Outside Mid-Continent Area
CHIKSAN COMPANY
Brea, Calif. Chicago 3, Ill. Newark 2, N. J.
Export Sales: CHIKSAN EXPORT COMPANY, Brea, Calif. Newark 2, N. J.

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Manufacturers and Distributors of Oilfield, Refining, Marine and Industrial Equipment

The MONTH . . .

ucts as the effective manner of encouraging refining companies to materially expand their capacities. Unless companies could anticipate a fair return on investments represented by expanded capacity they would not make the effort in spite of government aids already available, he thought.

Apjohn also mentioned growing shortages of sulfur, and tetraethyl lead. Short materials holding down aviation and jet fuels production he said are metallic lead, metallic sodium and ethyl chloride. He reiterated PAD's goal of 700 thousand barrels-a-day new refining capacity as the goal for 1952.

Basic Refining Cut Off Amortization Privilege

A limited supply of construction materials has been given as the reason for the absolute ceiling of one million barrels-a-day on basic refining capacity effected by PAD. Only those projects under processing on April 30 will be considered for fast tax write-offs. PAD officials estimate that 370 thousand barrels refining capacity has already been granted certification and that applications in process would boost the total to more than one million barrels daily. Interior Secretary Chapman and Deputy Administrator Brown both emphasized that this policy affected only basic refining projects.

Refining Expansion to Add Million Barrels by 1953

Expansion of refining facilities outside the United States will have increased total world petroleum capacity by more than 1 million barrels daily in 1953 according to Eugene Halman, president of Standard Oil Company of New Jersey.

World consumption of petroleum products, he said, amounts to nearly 4 billion barrels a year, and new oil production, refining and transportation facilities are being added to keep pace with growing demand. While proved oil reserves are estimated at a minimum of 80 billion barrels, Holman scoffed at the idea that we would face a deficit in 20 years, for he said, "more oil has been discovered each year for the past 50 years than has been consumed during the year, with one or two exceptions."

API Anticipates Increased Refinery Capacity in 1951

An increase of 3.9 percent in refinery capacity over 1950 figures is in prospect this year according to API statistics. Figures for this year do not include projects approved to date by DPA and which may be completed this year; or 126,000 barrel per day capacity shutdown as of December, 1950, for repair; or "any bottleneck removal that may be accomplished as a result of studies of the refining subcommittee of National Petroleum Council's 'Million Barrel Committee'."

The figures released do include about 147,000 barrel-a-day capacity shutdowns in December, 1950, operable but believed to be mainly high cost mar-

The MONTH...

ginal capacity. Capacity last December totaled 6,856,950 barrels a day, and by December, 1951, it is anticipated the capacity will reach 7,061,350 barrels. The capacity of crude oil charged directly to cracking units was 473,000 barrels last December and is expected to continue at about the same rate. This activity is largely centered on the East coast, 100,000 barrels, and the Gulf Coast, 275,000 barrels.

McGrath Heads Braun Project-Engineering

Philip C. McGrath, formerly chief processing engineer for C. F. Braun & Co. of Alhambra, Calif., now heads the company Project-Engineering department. He has been with Braun for 22 years.

McGrath

After graduation from Massachusetts Institute of Technology in 1925 he joined the Louisiana Oil Refining Corporation in Shreveport, La., as process-engineer, and later operating-supervisor and assistant chief-engineer in charge of process-design. He joined Braun as process-engineer.

McGrath's new duties include responsibility for Project Division's production as well as guidance of the Project-Engineering department.

Fluor Starts 8000-Barrel Woods Cross Cat Cracker

Fluor Corporation of Los Angeles has been given contract to build a 8000-barrel catalytic cracking unit at the Phillips Petroleum Company's plant at Woods Cross, near Salt Lake City. Construction will start in August and the unit is scheduled for completion in May, 1952. Engineering work is already under way.

Phillips also plans to add a vacuum plant, a gas plant and storage facilities to the refinery.

Du Pont Opens New Lab

Du Pont's new $30 million Experimental Station addition was dedicated early this month. Located at Wilmington, Del., the expanded station is near the site of the company's original plant and constitutes one of the largest research establishments in America. Nineteen buildings were constructed in the expansion program, nine laboratory buildings and ten service buildings.

Sinclair Expands Research

All Sinclair Oil Corporation research activities will be centralized in a new subsidiary, Sinclair Research Laboratories, Inc., according to E. W. Isom, chairman of the new company, and P. C. Spencer, president. The change is being made to facilitate expansion of research facilities and technological personnel.

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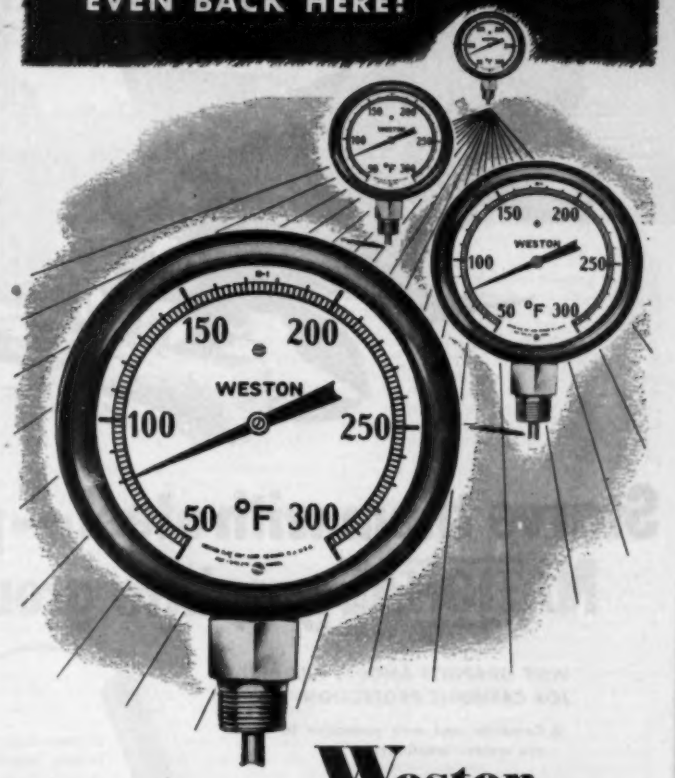

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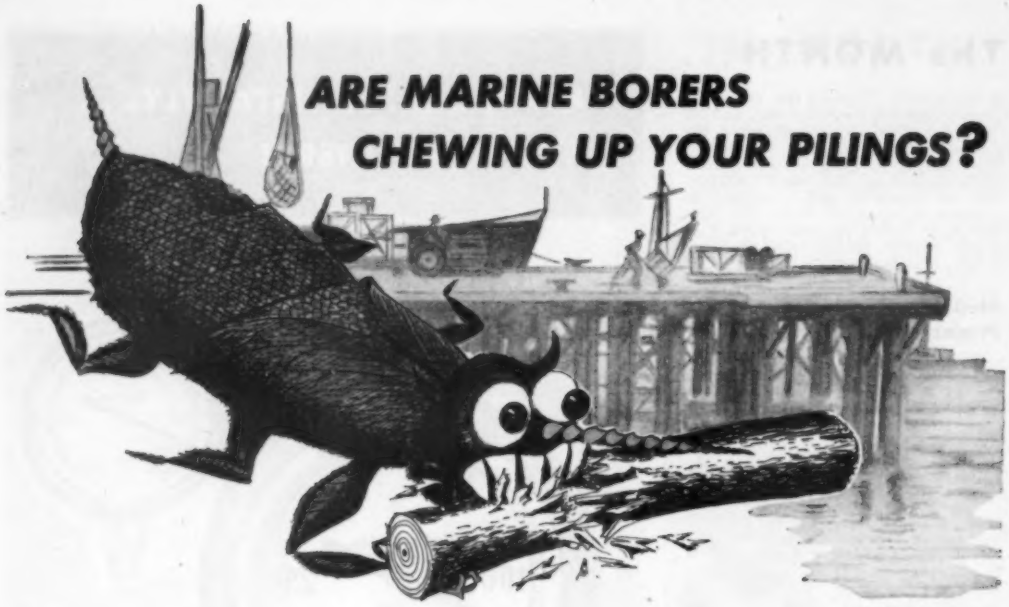

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SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

Manufacture: Processes and Plant

Boiling Coefficients of Heat Transfer. C_4 Hydrocarbon-Furfural Mixtures Inside Vertical Tubes. W. E. BONNET AND J. A. GERSTER. *Chem. Eng. Progress*, **47** (1951), pp. 151-8.

Although there have been several investigations of the evaporation of pure liquids in forced convection inside vertical tubes, data for boiling-heat-transfer coefficients for the case of liquid mixtures of widely different volatilities are not readily available. The system studied in this case was a C_4 hydrocarbon in furfural. The reboiler used was a vertical, once-through, forced-circulation type. The boiling coefficient was found to increase with increasing vaporization of small amounts of a volatile component from a solution containing a large amount of a relatively less volatile component. A large part of the heat transferred was used as sensible heat to increase the temperature of the unvaporized portion. The factor most affecting the heat transfer coefficient was the actual volume of vapor evolved. Data are presented in considerable detail and a bibliography of 21 references is given.

Design of Packed Distillation Columns. II. Operating Vapour Rates for Packed Distillation Columns. C. H. G. HANDS AND F. R. WHITT. *Jour. of Applied Chem.*, **1** (1951), pp. 19-25.

Relatively simple correlations of the important variables associated with allowable vapour velocities in packed columns are presented. If the column is operated at about 2/3 the rate calculated from the equation, lb.-mols./sq. ft./hr. $= 1/3 \sqrt{}$absolute pressure of distillation, mm. Hg. the results are found to be satisfactory for columns operating at atmospheric pressure or vacuum. Calculations from an entrainment formula gives results leading to substantially the same conclusions. Data from the experimental work are presented in some detail in tabular and graphical form and a bibliography of 15 references is appended.

Separation of Gas Mixtures By Mass Diffusion. Part II. MANSON BENEDICT AND ARNOLD BOAS. *Chem. Eng. Progress*, **47** (1951), pp. 111-22.

The previous paper described equipment to separate gas mixtures by either the column or the stage type of mass diffusion process, and covered the theory of the separation of isotopic mixtures by a cascade of mass diffusion columns. The present article continues the discussion of the separation of isotopic mixtures, and then considers the extraction of hydrogen from gas mixtures by each type of mass diffusion. A bibliography of seven references is given.

Sweep Diffusion Gas Separation Process. Part II. MARIO T. CICHELLI, W. D. WEATHERFORD, JR., AND JOHN R. BOWMAN. *Chem. Eng. Progress*, **47** (1951), pp. 123-33.

In a previous article, the theoretical analysis of a gas separation process known as "sweep diffusion" was given. The present paper is concerned with the experimental work, including the comparison of theory with experimental results, with applications, and with conclusions to be drawn. Sweep diffusion is a continuous differential column type gas separation process through which a gaseous mixture can be separated into components as completely as desired. It can also be used for removing suspended solid or liquid particles from a gas stream. Since the process is thermodynamically irreversible, it is characterized by a relatively large energy requirement, and its commercial application is therefore probably limited to separations that cannot easily be performed by the more standard processes of distillation, absorption, and adsorption. The investment in plants would be relatively low. The energy required can be supplied by low quality material such as exhaust steam. A bibliography of ten references is included.

Temperature Gradients in Gas Streams Flowing Through Fixed Granular Beds. C. A. COBERLY AND W. R. MARSHALL, JR. *Chem. Eng. Progress*, **47** (1951), 141-50.

The paper reports the results of an experimental study of the temperature gradients in gas streams flowing through granular beds. Results are expressed in terms of the effective thermal conductivity of a granular bed through which gas flows and are correlated as the functions of packing size and air velocity. A method is given for estimating the heat-transfer coefficient of the gas film on the inside wall of a packed tube. Measurements of the velocity distribution of air flowing through packed tubes appears to justify the assumption that rod-like gas flow occurs.

Production of Ethylene By Autothermic Cracking. R. M. DEANESLY AND C. H. WATKINS. *Chem. Eng. Progress*, **47** (1951), pp. 134-40.

The name autothermic cracking is given to processes in which the endothermic heat of cracking is furnished by introducing air or oxygen with the feed so that through the heat furnished by combustion the over-all reaction is self-sustaining. The yield and product distribution obtained in pilot plant work under varying ratios of air to hydrocarbon are presented and discussed for processing propane or ethane to make ethylene. Ethane conversion up to 96 percent per pass are obtainable. This compares with 50 to 60 percent in tubular reactors. Dilute feeds containing as little as 50 percent ethane can be cracked satisfactorily. When treating propane, butane, and heavier stocks, the C_2 fraction contains 92 to 94 percent ethylene as compared with 75 to 80 percent when using tubular furnaces. The data are presented in some detail, largely in graphical form.

Separation of Sulfur and Aromatics from Petroleum with Boron Fluoride and Hydrogen Fluoride. E. C. HUGHES, W. E. SCOVILL, C. H. WHITACRE, R. B. FARIS, J. D. BARTLESON, AND S. M. DARLING. *Ind. Eng. Chem.*, **43** (1951), pp. 750-3.

The work reported was undertaken in an effort to provide information on a method of separating sulfur compounds through the use of boron fluoride and hydrogen fluoride. Aromatic, as well as sulfur-containing compounds were substantially removed by this solvent system. Complexes are formed with aromatics and sulphur compounds in the same way as with aluminum chloride catalysts. These compounds can be disassociated at higher temperatures with the recovery of the reagents. It is believed possible to use these reagents for large scale separations of sulfur and aromatic compounds. In such application

These abstracts from the current literature of science and technology (not including trade journals easily available) were prepared by Drs. Leslie and Coats of The Leslie Laboratories, Traver Road, Ann Arbor, Mich., which will supply, at cost, photostatic copies of original articles. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also may be had by arrangement with the laboratories.

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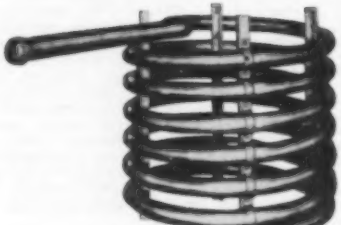

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the process is in competition with solvent extraction processes. The reagent is, however, highly selective and easily recoverable. Preparation of kerosenes and lubricating oils of high quality is suggested as possible applications for the reagent. The use of hydrogen as a gas in admixture with boron fluoride as liquid was investigated and satisfactory results were obtained upon treating relatively high sulfur crude. Data are presented in considerable detail in tabular form and a bibliography of 15 references is included.

Lower Paraffin Hydrocarbons. Catalytic Conversion by Boron Fluoride with Hydrogen Fluoride. E. C. HUGHES AND S. M. DARLING. *Ind. Eng. Chem.*, **43** (1951), pp. 746-50.

The thermal reforming of lower paraffin hydrocarbons such as the naphthas results in higher knock-rating gasoline, but is accompanied by loss in the form of gas. The work reported was undertaken in an effort to find a new method that would not have this objectionable loss feature. The authors studied the reactions of propane, butane, pentane, and heptane in the presence of hydrogen fluoride-boron fluoride and it is shown that boron fluoride with a hydrogen promoter behaves as a typical Friedel-Crafts catalyst in effecting the conversion of hydrocarbons. The authors conclude that the procedure provides an alternative method for isomerizing the lighter hydrocarbons. The fact that the reagent can be recovered by distillation provides some advantage over the presently used aluminum halide system. The parallelisms of the results obtained with boron fluoride and those secured with the aluminum halide are striking, and it is believed are in agreement with those for which a carbonium ion mechanism has been proposed. A bibliography of 34 references has been included.

Chemical Composition and Reactions

Dithionethiophanes. WALTER FRIEDMANN. *Jour. Inst. of Petroleum*, **37** (1951) pp. 40-3.

In studying the reactions between 2:2:4-trimethylpentane and sulphur, under certain conditions, the author observed two isomeric compounds, having the empirical formula $C_8H_{16}S_2$. One of the isomeric substances, melting at 86° C, can be considered as belonging to the dithione-thiophane series. The other isomer contains a sulphydril group, as was ascertained by alkaline sodium nitroprusside and by infra-red absorption spectrum.

Reaction of Isoalkanes and Olefin Precursors Catalyzed by Sulfuric Acid. ROBERT F. MARSCHNER AND D. R. CARMODY. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 604-7.

Alkylation of alkanes by olefin can occur by combination of two molecules of alkane and one of olefin, or one of alkane and one of olefin. Few studies have been made using sulfuric acid as catalyst, although many have been made using aluminum chloride. The authors

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used various alcohols as olefins precursors, and also used butyl chloride. It was found that the reactions resulted in approximately twice as much isoalkane consumption as is required by the simple addition of the olefin. Isoalkane was synthesized in amounts almost equivalent to alkene consumed. Also alkanes with twice the carbon content of the initial isoalkane were produced. These results can be explained on the basis of the Whitmore carbonium-ion hypothesis, employing hydrogen transfer concepts as advanced by Schmerling, and also assuming that the essential reactions are rapid and reversible, and that the system reaches a state of dynamic equilibrium. Results of the work are presented in some detail in tabular form.

Products: Properties, Utilization and Analysis

Antiknock Antagonists. H. K. Livingston. *Ind. Eng. Chem.*, **43**, (1951), pp. 663-71.

The efficiency of tetraethyllead and some other antiknock compounds is decreased by antagonists such as sulfur compounds, some organic chlorides and bromides, phosphates, phosphites, peroxides and some arsenics and silicates compounds. In general, sulfur, phosphorus, and halogen compounds are antagonists for metallic antiknocks, but have little effect on the octane number of fuels containing no antiknocks or nonmetallic antiknocks. The antagonists for tetraethyllead (listed in the order of the harm done by them) are: phosphates, phosphites, silicates, silicanes, arsines, mercaptans, disulfides, sulfide, thiophene, and organic halides. Based on these facts a mechanism to explain antiknock action is proposed. It is believed that further work may lead to an understanding of processes involved in the phenomenon of knock and in the suppression of knock by chemical antiknock compounds.

Analytical Distillation. *Analytical Chemistry*, **23** (1951), pp. 529-30.

This is a report of the round-table discussion held by the Division of Analytical Chemistry at the 118th Meeting of the American Chemical Cociety in Chicago, September, 1950. Among the topics considered were concentric-tube columns, non-adiabatic operation of concentric-tube columns, metal screen columns, spinning-tube columns, total reflux distillation, mixtures for testing columns at atmospheric pressure and reduced pressure, and methods of interpreting distillation data. A bibliography of nine references is given.

Equilibrium Flash Still. R. B. Smith, Thorpe Dresser, H. F. Hopp, and T. H. Paulsen. *Ind. Eng. Chem.*, **43** (1951), pp. 766-70.

An equilibrium flash still for laboratory studies is described. Mercury vapor is used as the heating medium, and the heating zone was maintained at constant temperature. Temperatures were used in the range from 400 to 800° F. and pressures from atmospheric down to 1 mm. absolute. Typical data as obtained from the study of a heavy petroleum stock are given to illustrate the operation of

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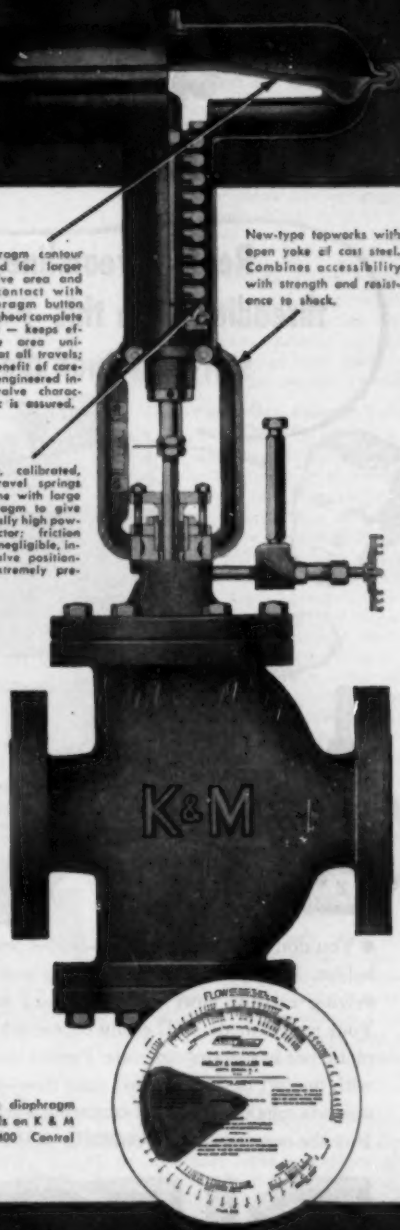
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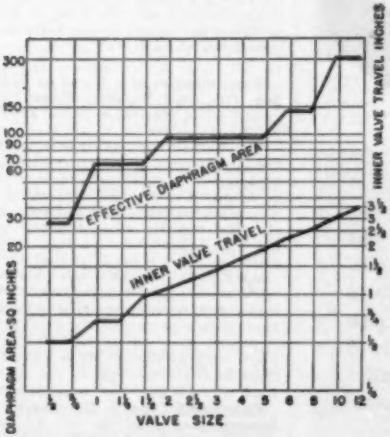

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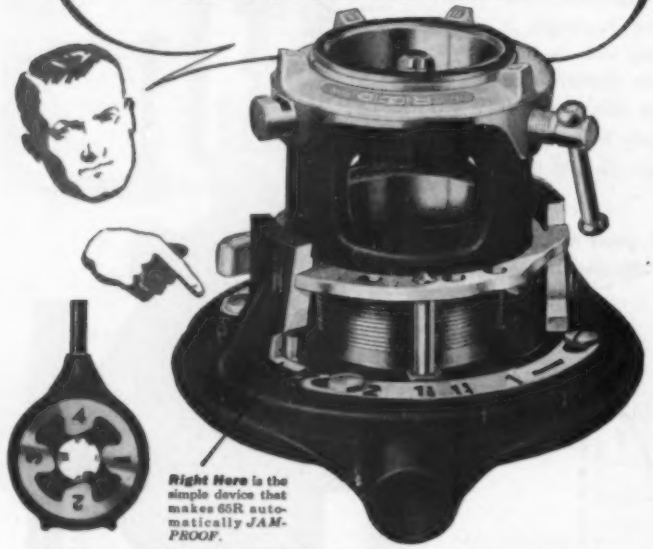

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this still and the reliability of the data obtained.

A Spinning-Band Column for Vacuum Fractionation of Fatty-Acid Esters. L. J. WILLIAMSON. *Jour. of Applied Chem.*, 1 (1951), pp. 33-40.

The author briefly reviews the literature of laboratory columns operating under relatively low vacuum and then describes a spinning-band column 16 mm. in diameter and 82 cm. long. Constructional details of the entire assembly of equipment are given. The H.E.T.P. of the column varied from 2.6 to 3.4 cm. as the vaporization rate varied from 200 to 400 cc. per hour. Under vacuum the H.E.T.P. was two to three times that at atmospheric pressure. Data are presented on various systems distilled. The author concludes the column is suitable for the analytical fractionation of fatty acid esters at pressures of the order of 1 mm.

Rotary Condenser Fractionating Vacuum Still. F. C. BENNER, A. DINARDO, AND D. J. TOBIN. *Ind. Eng. Chem.*, **43** (1951), pp. 722-7.

The design and construction of a rotary condenser thermal rectification still are presented and the operating problems are discussed. The still was evaluated at atmospheric pressure and operated at still head pressures in the range 0.005 to 1.5 mm. In the low pressure range, enrichments accomplished corresponded to separations that would be effected by 18 "theoretical plates." Pressure drop through the column from the still to the column head is of the order of 0.2 to 0.5 mm. Temperature gradients in the reflux film and in the condenser are reported. Their effect on control problems is discussed. A binary test mixture composed of n-hexadecane and l-hexadecene is described and is thought to be useful for evaluating stills operating at low pressure.

Determination of n-Paraffins in Gasoline, Oils, and Paraffin Waxes. WOLFGANG LEITHE. *Analytical Chem.*, **23** (1951), pp. 493-5.

The author believes that a workable chemical method for determining the contents of n-paraffins and isoparaffins in mixtures is a valuable working tool. The procedure described is based on the chemical reaction with antimony pentachloride, followed by an indirect determination of the n-paraffins that have not reacted with the antimony compound, while the iso-paraffins are converted into insoluble tarry material. The accuracy is about 3 to 6 percent of the total sample. Aromatic and oxygenated compounds react with antimony pentachloride and must be first removed.

Compound Types in Gasoline by Mass Spectrometer Analysis. R. A. BROWN. *Analytical Chem.*, **23** (1951), pp. 430-7.

Gasoline distillates and petroleum solvents can be analyzed according to compound type on a Consolidated Model 21-101 mass spectrometer equipped with a modified inlet system. Component hydrocarbons, such as aliphatic paraffins; cyclo-paraffins and/or mono-olefins; cyclo-olefins, diolefins, and/or acetylenes; and aromatics are determined within ± 4 percent. Three man-hours are required for a complete analysis. Mono-

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Keeping Equipment In Efficient Operation

At the annual conference and exhibition of the National Association of Corrosion Engineers held at Hotel Statler, New York, March 13-16, we asked many of the visitors at our booth what problems were uppermost in their minds. Keeping equipment in efficient operation with the minimum of shutdowns is the objective of operators. Corrosion is the greatest menace to the life of equipment. Not only is the selection of the corrosion-resisting materials of paramount importance but careful control and understanding of operating conditions are most essential.

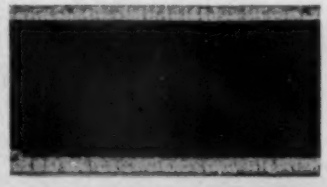
Unfortunately, there are many uncontrollable factors resulting from changes in operating conditions which affect the corrosive character of solutions and make maintenance troublesome. Changing conditions naturally affect the corrosion rate.

The need for greatly increased production often taxes the available equipment since the output is much greater than the equipment is designed to handle. The corrosion rate from the product side is greatly speeded up and the life of the equipment is proportionately reduced.

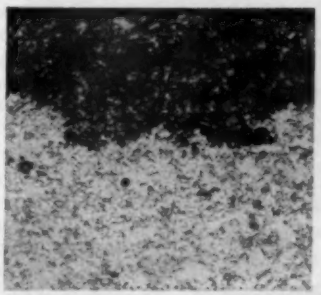
The handling of larger quantities of products generally requires greater cooling or heating capacities which are obtained by increasing the water or steam velocities. In some cases the higher velocities may tend to keep the tubes cleaner and are, therefore, beneficial. Again, exceptionally high water velocities may tend to accelerate impingement corrosion and shorten the service life of the tubes. When the impingement attack is at the inlet ends of the tubes, the use of inserts to take the brunt of the attack is recommended. Inserts are replaceable when the useful life of the old ones is destroyed.

Dezincification Can Be Reduced

Sometimes an alloy is used which is not suitable for existing conditions. Dezincification has occurred in tubes, and other parts of equipment made from uninhibited high-zinc-content brasses, especially when in contact with non-scaling types of waters. By using inhibited alloys, as for example, arsenical admiralty, arsenical aluminum brass, dezincification can be reduced or entirely eliminated. Arsenical copper and



Bottom half, longitudinal section of yellow brass pipe showing nodules of corrosion products covering areas of plug-type dezincification developed on the floor of the pipe. Note absence of nodules in top half of pipe.



"Layer-type dezincification" is recognized by relatively thick layers of deposited copper built up over a period of time. Micrograph mag. 75X.

red brass (85% copper, 15% zinc) will give much longer life in most waters than uninhibited yellow brass or uninhibited admiralty.

Trouble is experienced from paper mill liquors during the recovery cycle, primarily because of the presence of sulphides and other sulphur compounds. The steam coming from the evaporators containing much H_2S gas is well resisted by Muntz metal. 70-30 cupro nickel has given satisfactory service for handling "white liquor."

River water contaminated with sulphide wastes may also attack copper tubes. Admiralty, Muntz, and aluminum brass inhibited with arsenic are superior to copper for this condition.

Vibration Often Causes Tube Failure

Some operators are having trouble from excessive vibration of the tubing in condensers and heat exchangers. This occurs more often in re-tubed equipment where the holes in the support plates may have been enlarged, permitting a loose fit. Or the position of the support plates may have been moved, thus changing the vibration characteristics of the tubes. Periodic vibration is set in motion through the pulsating action of pumps, compressors, motors, or other equipment in proximity to the tubes. Sometimes it is helpful to change the speed of the pumps or motors to stop the tubes from vibrating excessively. Additional support plates or relocation of the support plates sometimes help.

Duplex Tubing Solves Double Corrosion Problems

To overcome the corrosive effects from gaseous hydrochloric acid either dry, wet, or mixed with other gases, Duplex Tubing with nickel to the hydrochloric acid side and a copper-base alloy to the water side is recommended. For sulphuric acid solutions, Duplex tube with lead to the acid side and copper to the steam or water side is superior to most other metals for this type of corrosion.

Steam erosion resulting from the impingement of wet, corrosive steam on condenser tubes sometimes gives trouble. Grids or deflector plates in the path of the steam will help protect the tubes. Sometimes a change in alloys is necessary. Where the corrosive agent is a trace of ammonia, 70-30 cupro nickel is superior to copper or the brasses. Where CO_2 in the steam is the corrosive agent, Duplex tubes with stainless steel outside and a copper-base alloy inside are called for. (5645)

Here are 25 different steel tubing analyses

Let us help you pick the best for your job

Low Carbon
Low Carbon, ½ Mo
Low Carbon, 1 Mo
½ Cr, ½ Mo
1¼ Cr, ½ Mo
2 Cr, ½ Mo
2¼ Cr, 1 Mo
2½ Cr, ½ Mo, ¾ Si
3 Cr, ½ Mo, 1¼ Si
3 Cr, 1 Mo
5 Cr, ½ Mo
5 Cr, ½ Mo, 1½ Si
5 Cr, ½ Mo, Ti
7 Cr, ½ Mo
8 Cr, ½ Mo
8 Cr, 1 Mo
9 Cr, 1 Mo
12 Cr, Al
17 Cr
27 Cr
18-8
18-8 Ti
18-8 Cb
18-8 Mo
25-20

If you select steel tubing for refinery operations, you undoubtedly have a good idea of the possibilities and limitations of certain analyses.

But you can't possibly spend the time to learn how each analysis stands up under the many combinations of heat, pressure, and corrosive chemicals.

That's where we can help you. We have a tremendous file of authentic case histories dealing with different steel tubing analyses. If you have a problem, we may be able to offer a complete record of several analyses that have been used for that specific application.

This information is particularly valuable today, when certain grades of steel are in short supply. We can help you select alternates that will often do as good a job, sometimes at an even *lower* cost.

So make National Tube Company your headquarters for up-to-date, reliable information on steel tubing. There's no obligation, of course, and we'll be glad to give you all the help and information that we can. Write for Bulletin Number 26. Address National Tube Company, Frick Building, Pittsburgh 19, Pa.

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UNITED STATES STEEL

olefins are determined by bromine number or nitrosation, and the sample required is only 0.001 ml. The author is of the opinion that the method can be used directly by other mass spectrometer users. Also, the same principle can be extended to obtain type compound analysis of higher boiling petroleum fractions and mixtures of nonhydrocarbon compounds. The data secured from the work are presented in considerable detail in tabular and graphical form, and a bibliography of 17 references is included.

Infrared Analysis of Five C_{10} Aromatics. JOHN A. PERRY. *Analytical Chemistry*, **23** (1951), pp. 495-7.

The need for a method of analyzing mixtures of isomeric, butyl and diethylbenzenes boiling between 165° and 190° C. led to the development of a method for the determination of the composition of such mixtures. The procedure is simple, rapid and accurate. No dilution of the sample is required. The accuracy compares favorably with similar reported work; the error is 0.5 percent absolute over the entire range percentage. The validity of Beer's law is assumed, and also it is assumed that no knowledge of the length or absorbancy of the rock salt cell is required. Typical data are presented and a bibliography of ten references is appended.

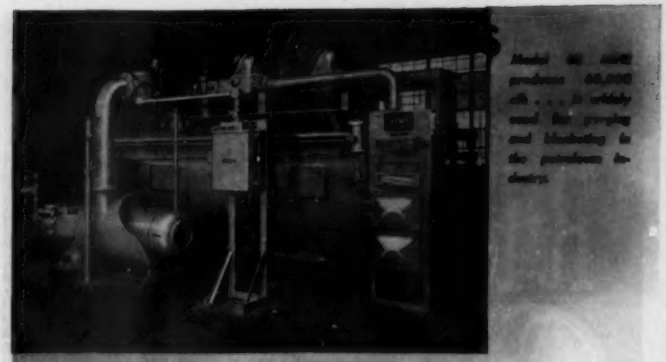
A Method for Evaluating the Oxidation Stability of Inhibited Transformer Oils. G. H. BEAVEN, R. IRVING, AND C. N. THOMPSON. *Jour. Inst. of Petroleum*, **37** (1951), pp. 25-39.

One of the most important and fundamental properties of a transformer oil is its stability towards oxidation. Physical properties of an oil, such as viscosity, volatility, pour point, etc. depend upon the choice of feedstock distillate. The chemical and electric properties, such as acidity, dielectric strength, resistivity, etc., are determined principally by the refining treatment to which the stock is subjected. The oxidation stability depends both on the feedstock and on the refining treatment. A procedure is de-

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Methyl erucate
Iron dithionate
Pentachlorobenzaldehyde
1,2-Diketohydrindene
1,4-Diaminopentane
trans-1,2-Cyclopentanedicarboxylic acid
Triethylphenyl germanium
Ethenyltricarboxylic acid
trans-beta-Decalone
2,8-Chrysoquinone
2-Methyl-5-vinylpyridine
Tetracosane
Tetramethylethylene
4-Heptanethiol
2,6-Difluoro-1,4-dimethylbenzene
1,7-Diiodoheptane
Dipropenyl ketone
Cyclobutane.



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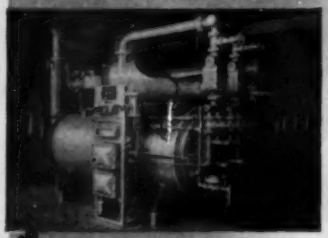
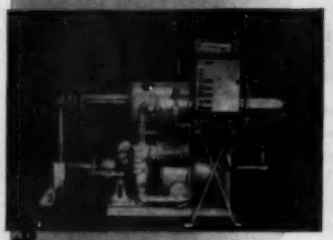


Model 6 MIGE is ideal for agitating, bubbling and blanketing in synthetic resin plants . . . delivers 6000 cfh.



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scribed for evaluation of the oxidation stability of inhibited transformer oils by measurements of their rates of oxygen absorption. Under the experimental conditions described, the oxygen absorption/time curves show well-defined induction periods before the onset of the oxidation reaction proper, and the consequent formations of acid and sludge. The induction period is an important criterion in the evaluation of inhibited oils. It is considered to be a measure of the susceptibility of an oil to any particular oxidation inhibitor. Data are given that show the response to a particular inhibitor, of transformer oils refined to varying degrees, the response of a particular oil to varying concentrations of inhibitor, and the relative effects of the use of different inhibitors. A correlation was established between tests in which soluble copper and solid copper catalysts were used. A bibliography of 16 references is appended.

Fundamental Physical and Chemical Data

Critical Behavior and Liquid-Vapor Equilibrium in Mixtures of Fluids. CHARLES A. BOYD. *J. Phys. & Colloid Chem.*, **54** (1950) 1347-57.

The author developed the thermodynamics of the liquid-vapor equilibrium using van der Waals equation of state. A mathematical treatment is presented for simple and for binary systems. The ethane-heptane system is taken as an example and the results of calculation are compared with experimental data.

The Thermodynamic Properties of Naphthalene. GORDON M. BARROW AND A. L. MCCLENNAN. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 573-5.

The heat of vaporization of naphthalene was measured and found to be 11,086± 30 cal/mole at 209 mm. pressure and 440.9° K. The specific heat of the vapor was determined at 451.0 and 522.7° K. and from these data the heat capacity in the ideal gas state at these temperatures was obtained. Values of the entropy and heat capacity of solid and liquid naphthalene were taken from the literature. These, together with the

Ohio Altitude

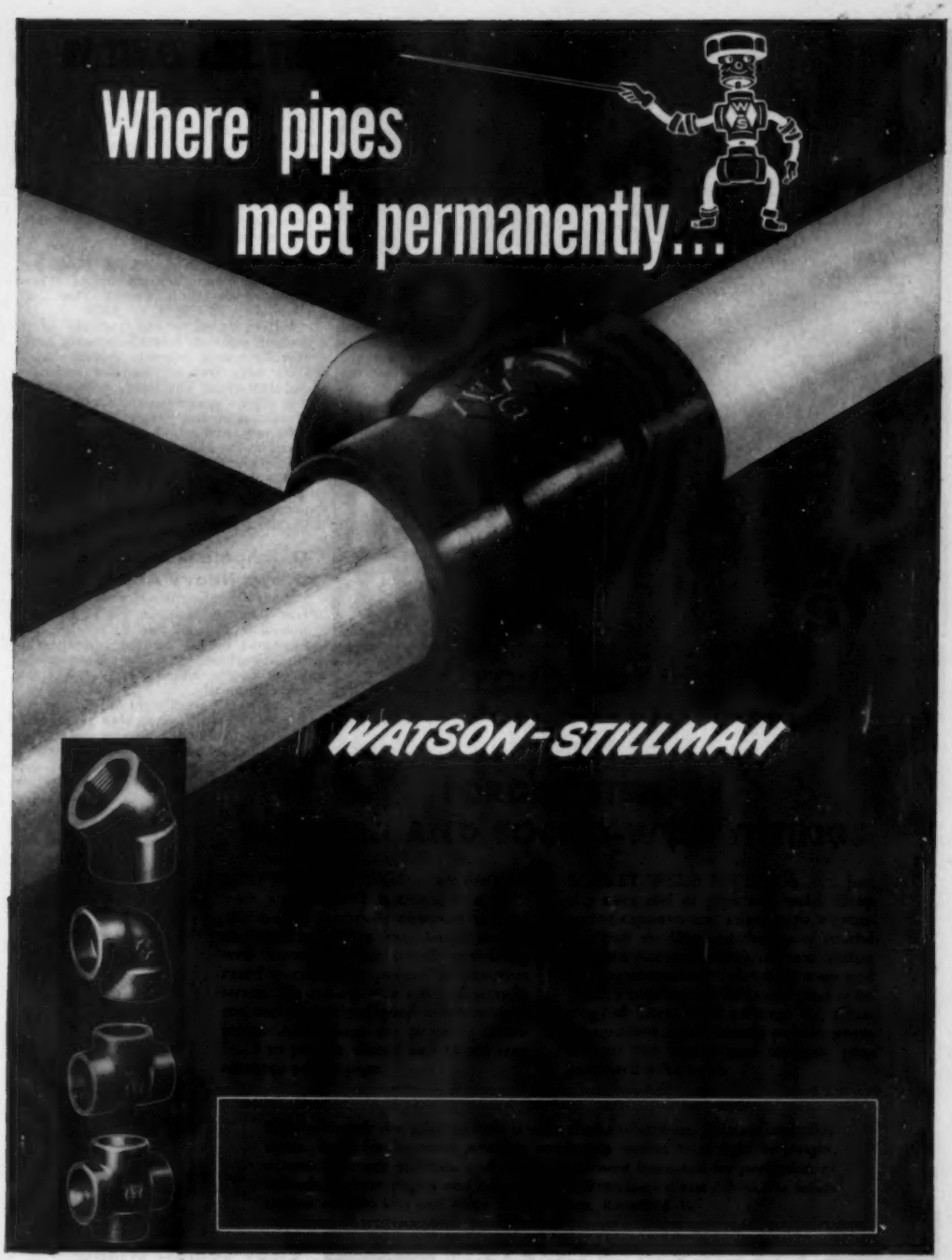
To the Editor:

An article in the March, 1951 issue of PETROLEUM REFINER on page 96 states "the new 265 foot unit . . . "is" . . . the tallest industrial structure in the state."

May I point out that in March, 1950, a 28,000-barrel-per-day Houdriflo catalytic cracking unit went on stream in the Sun Oil Company Toledo refinery. This quadruple unit has been running very satisfactorily since. Its height is 312½ feet above grade. As far as I know this unit is the tallest industrial structure in the state, if not in the country.

SUN OIL COMPANY,
John F. Harron,
Superintendent.

Toledo 1, Ohio.
March 29, 1951.



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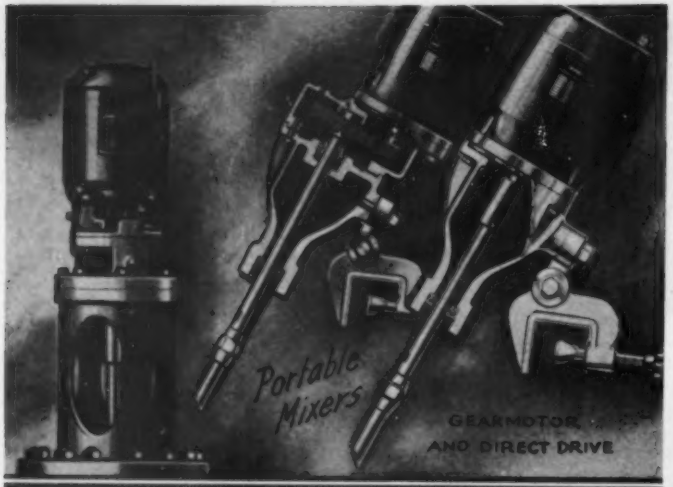

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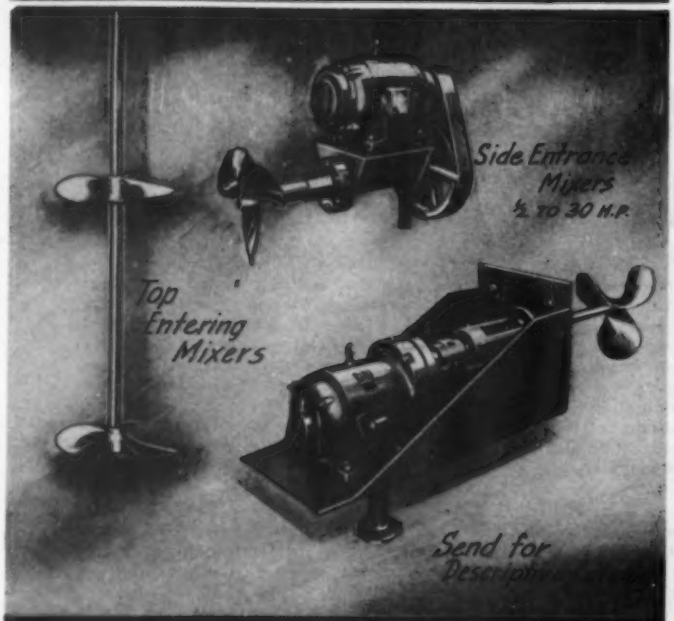

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experimentally determined heats of vaporization, were used to calculate the entropy of naphthalene in the ideal gas state at 440.9° K. The value is 95.9± 0.4 cal/deg. mole. Thermodynamic functions of naphthalene were calculated from spectroscopic data for the temperature range 298.16 to 1500° K. Calculated values agree well with experimentally determined values.

The Vapor Pressures of Hydrogen, Deuterium and Tritium up to Three Atmospheres. E. R. GRILLY. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 843-6.

Fifteen cc. of tritium from the Li^6 + neutron reaction recently became available for vapor pressure measurements. Data were also obtained for hydrogen and deuterium. The author presents data that allows a comparison of the vapor pressures of the three isotopes up to 2100 mm. and which also can be compared to the calculated values of others. Triple points and heats of vaporization and sublimation were calculated from the vapor pressure data. The data are presented in some detail in tabular and graphical form.

Oklahoma Gas Course Draws Heavy Attendance

James L. Griffin, Northern Natural Gas Company, Omaha, Nebr., has been named to succeed Ben F. Worley, 1951 chairman of the general committee of the Southwestern Gas Measurement Short Course which meets at Norman, Okla., annually.

This year's enrollment of 942 exceeded any past record; members represented 34 states as well as five foreign countries. Seventy separate classes were held which 30 manufacturing concerns supplied exhibits of equipment for examination.

Miss Kate A. Niblack, secretary of Oklahoma Utilities Association for 25 years, was recognized by the general committe for her long service. Proceedings of the Course will be published in bulletin form acording to T. S. Whitis, chairman of the publications committee.

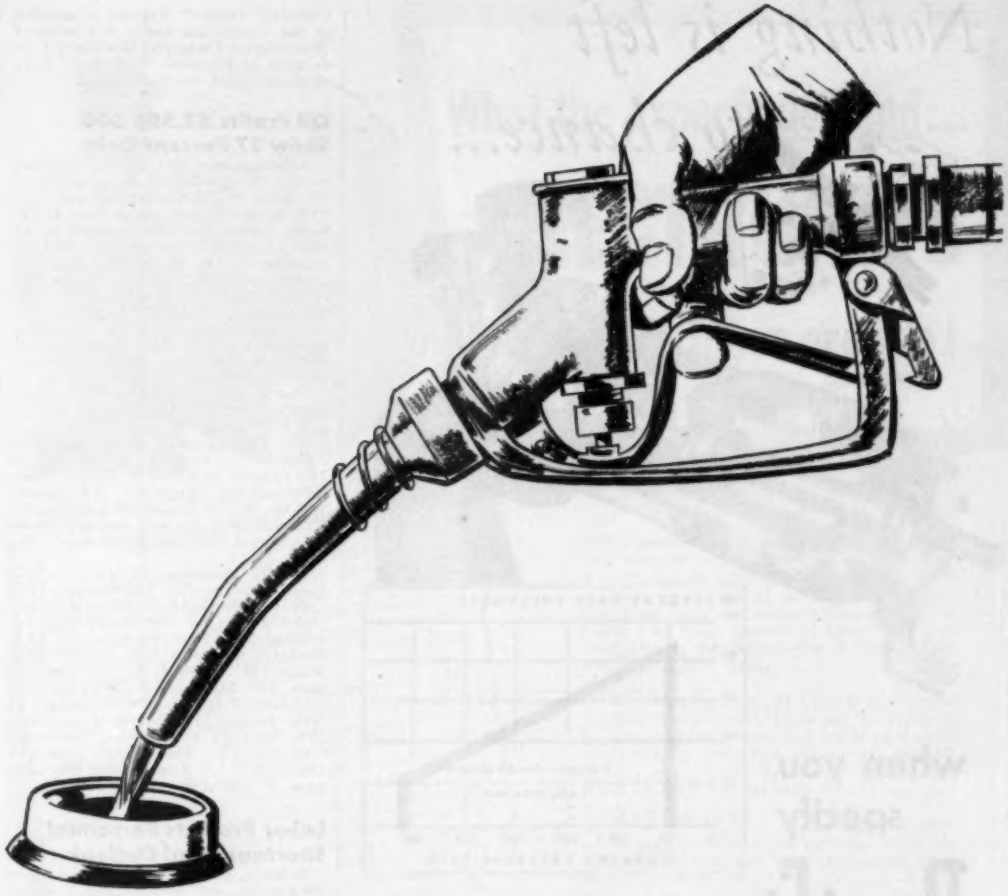
Adams New Sloan Fellow

Edward E. Adams, Standard Oil Company of California, was awarded one of 14 annual Sloan Fellowships to study at Massachusetts Institute of Technology for one year. The fellowships were established by the Alfred P. Sloan Foundation in 1931 for the purpose of broadening the experience of young executives with several years business training.

Adams, a petroleum engineer, was the only candidate selected from industry west of the Mississippi River. He lives in Taft, Calif., but for the past eight months has been on special assignment in Standard's San Francisco office. He will study management, economic and social problems of industrial administration at MIT.

Essay Contest Winner

The Hydraulic Institute at Santa Barbara, California, has awarded Robert H. Rhodes the $200 first prize in the seventh Annual Essay Contest sponsored by the institute. His winning paper was entitled, "Shaft Sealing on Centrifugal



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The effectiveness of Santolene C has been proved in the laboratory and in the field. These findings have been confirmed by a major oil company which has marketed Santolene C in all types of light petroleum products for more than a year.

Santolene C is product-soluble. It burns completely with the fuel, leaving no residues whatever. Diesel and gasoline engine tests have demonstrated that Santolene C has no effect on engine cleanliness, injector fouling or any other factor of engine performance.

For technical information on the use of Santolene C to solve corrosion problems, write, wire or telephone MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1775-E South Second Street, St. Louis 4, Mo.

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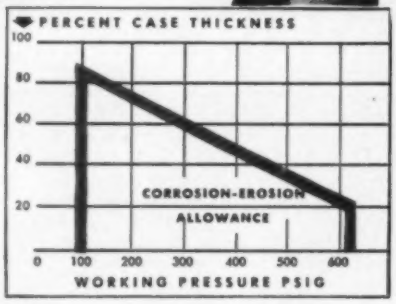

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PR-11

Chemical Pumps." Rhodes, a member of the centrifugal pump division of Worthington Pump and Machinery Corporation at Harrison, N. J., is on leave of absence with the U. S. Navy.

Oil Profits $2,508,000, Show 37 Percent Gain

Although the petroleum industry ranked 19 in a list of 21 industries on the basis of 1950 profits increase over 1949 figures, it ran second only to the motor vehicle and parts industry on the basis of actual dollar profits. With an increase of only 37 percent over 1949 profits, petroleum dollar profits for 1950 totaled $2508 million while motor vehicle profits totaled $3185 million. The only other industries to top the million mark were food, textiles, chemicals, iron and steel, fabricatel metal, nonelectric machinery and electrical machinery.

The average percent of 1950 profits increase over 1949 was 61 percent FTC and SEC survey showed.

The 1950 earnings of 20 major oil companies averaged an increase of 24.3 percent according to another tabulation. Jersey Standard's 51.8 percent was the largest. Union Oil Company of California was the only company listed to report a recrease in earnings. The list:

Atlantic Refining Company, 50.1; Cities Service, 2.9; Continental, 17.5; Gulf Oil Corporation, 10.2; Mid-Continent, 29.7; Ohio Oil, 11; Phillips Petroleum, 15.8; Pure Oil Company, 12.4; Shell Oil Company, 17.9; Sinclair, 29.8; Skelly Oil Company, 8.9; Socony-Vacuum, 30.4; Standard of California, 10.9; Standard of Indiana, 20.4; Standard of New Jersey, 51.8; Standard of Ohio, 25.3; Sun Oil Company, 44.1; The Texas Company, 12.3; Tide Water Associated Oil Company, 21.2; and Union Oil Company of California, minus 16.3.

Labor Predicts Personnel Shortages and Outlook

Stillmen, treaters and boilermakers in oil refining and chemical industries, as well as oil well drillers and servicing technicians, were listed among "key" occupations that will develop manpower shortages in 1951 and 1952 because of growing mobilization demands, according to the Labor Department.

About 30,000 engineers will be needed in the near future to meet defense and civilian requirements, and estimates of upcoming graduates fall short of even peacetime needs, reported the Department. It was predicted that there would be a pinch in physicists and chemists as long as the mobilization program continues.

Head of Nooter Corporation Dies; Robert Ryan Elected

Elmer J. Nooter, president of Nooter Corporation, St. Louis, died last month after 25 active years engaged in the fabrication of tanks and pressure vessels used in the processing field.

Robert J. Ryan has been elected to succeed Nooter as president. A former executive vice president, Ryan has been associated with Nooter Corporation since 1923 when he was employed as an accountant. Ryan is a recognized authority on electric welding processes and has pioneered their applications in the industry.

What the experts demand...

ELECTRUNITE

Pressure Tubes provide!

Expanded Tube Joints

The making of expanded tube joints in tube sheets of unfired pressure vessels was discussed in a paper by **F. F. Fisher** and **G. J. Brown**, both of The Detroit Edison Company. The authors reviewed present-day practice of rolling-in such tubes and presented information gained from installing, retubing, testing and repairing many types of heat-exchangers.

They recommended that the optimum degree of expanding be determined by tests conducted in advance of actual rolling operations and that the information so obtained be recorded and made available to others. Preference is given to the automatic relay-operated technique for uniform tube rolling.

As to the finish to be given tube holes, it was pointed out that rolled joints are primarily friction joints and that their holding strength depends upon the pressure and roughness between the contacting surfaces. On the other hand, pressure tightness is best obtained by use of smooth contact surfaces. For example, relatively rough tube holes can be used in heat-exchanger work if the tubes are much softer than the tube sheet. But if the tube material is hard, greater movement is produced between the contacting surfaces, and the axial flow of tube metal may shear or smooth off any roughness of the tube hole. For this reason the tube holes in boiler construction are reamed cylindrical and smooth and the reinforcing grooves are placed near the zone of minimum movement of the tube metal.

In order to bring out the full strength of a joint without undue distortion or damage to the tube sheets and headers, the tube metal should be softer than that of the tube sheets or headers.

When power engineers describe the qualities they want in pressure tubes, it all adds up to a description of ELECTRUNITE Tubes. Look, for example, at the list of desirable properties abstracted from the paper delivered by F. F. Fisher and G. J. Brown, of Detroit Edison Company, at the Seventy-first Annual ASME meeting in New York . . .

PROVED . . . Over 250 million feet of ELECTRUNITE Pressure Tubes are in service in boilers, heat exchangers and condensers of all sizes, output, and types. Republic's research and experience assure you of field-proved tubes for every requirement.

SMOOTHNESS . . . tube contact surfaces are smooth and free from rolled-in scale and scale pits. Because ELECTRUNITE Pressure Tubes fit tube-sheet holes accurately, they roll-in tighter every time.

DUCTILITY . . . no other pressure tube can give you more ductile properties than ELECTRUNITE Tubes. They bend smoothly and uniformly to permit rapid fabrication and trouble-free erection. They are easy to roll-in, and provide maximum tightness in the tube sheets.

UNIFORMITY . . . ELECTRUNITE Pressure Tubes are uniform in grain structure, have predictable rolling-in characteristics . . . no slivers, hard spots, or scabs to cause costly delays. Wall thicknesses are uniform, tubes are fully concentric, tube strength is uniformly high.

Let us send you a copy of Bulletin BT-12 . . . it describes ELECTRUNITE Pressure Tubes for boilers and process equipment.

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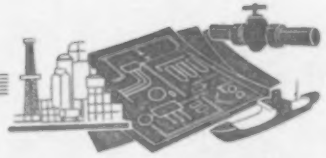
Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, February 13, 20, 27 and March 6, 1951.)



REFINING

U.S.P. 2,541,070. Method of Separating Dissimilar Components in Petroleum Products by Liquid Thermal Diffusion. A. L. Jones and E. C. Hughes to The Standard Oil Company (Ohio).

A liquid petroleum product comprising two dissimilar compounds, which are liquid under the separation conditions, is continuously introduced into a vertical slit having a width of 0.02-0.06 inch. The slit is formed by two smooth surfaces providing a temperature gradient across the slit by maintaining one of the surfaces at a higher temperature than the other. A fraction containing a greater concentration of one of the components is continuously withdrawn from one part of the slit, while a fraction containing a greater concentration of the other component is continuously withdrawn from another part of the slit. The rate of withdrawal is regulated in relation to the height of the slit, the temperature gradient, and the viscosity of the petroleum product.

U.S.P. 2,541,071. Continuous Method for Separating Materials by Liquid Thermal Diffusion. A. L. Jones and E. C. Hughes to The Standard Oil Company (Ohio).

The process according to this patent for continuously separating by thermal diffusion two liquid fractions of dissimilar materials included in a material liquid under the separation conditions is closely related to that of U.S.P. 2,541,070.

U.S.P. 2,541,338-40. Solvent Fractionation of Wax-Containing Mixtures. E. W. Clarke to The Atlantic Refining Company.

A wax-containing mixture is separated into fractions of higher and lower m.p. by countercurrently contacting it with an extractive solvent and solvent additives at a temperature such that two immiscible liquid phases are formed of which the one contains the wax of higher and the other that of lower m.p. After separating both phases, solvent and additive are removed from each of them. The solvent comprises 1.8-2.2 volumes of nitrobenzene containing a small amount of ethylene glycol monomethyl ether per volume of the charge mixture. The first additive comprises 0.15-0.25 volume of the same ether, and the second additive 0.85-0.95 volume of acetone containing a small amount of water. According to U.S.P. 2,541,339 the nitrobenzene solvent contains a small amount of phenol, the first additive is phenol containing a small amount of water, and the second comprises 0.45-0-55 volume of a paraffinic hydrocarbon with 8-18 C atoms. According to U.S.P. 2,541,340 the solvent comprises 2.6-3.4 volumes of phenol, the first additive comprises 0.25-0.35 volumes of water, and the second additive is the same as in U.S.P. 2,541,339.

U.S.P. 2,541,380. Solvent Extraction Process. O. L. Polly and C. H. O. Berg to Union Oil Company of California.

Two gaseous monoolefins with equal numbers of C atoms, e.g. 2-butene and 1-butene, are separated from one another by contacting their mixture with a diketone, such as acetonylacetone, which selectively dissolves one of the olefins.

U.S.P. 2,541,458. Recovery of Nitrogen Bases. C. H. O. Berg to Union Oil Company of California.

Hydrocarbon fractions containing nitrogen bases, such as are present in certain types of petroleum, shale oil, and tar sands, are extracted with an aqueous solution of a volatile acid boiling below 200° C. or of a non-volatile acid salt having a replaceable hydrogen and a mutual solvent for this extractive solvent and the hydrocarbons comprising a low mol. wt. monohydric alcohol or a ketone. The nitrogen bases are thereby completely removed from the hydrocarbon fraction.

U.S.P. 2,541,682. Production of Para Xylene. J. H. Arnold to California Research Corporation.

p-Xylene is recovered in a cyclic process from a hydrocarbon liquid comprising o-, m-, and p-xylene. The liquid is cooled to —75° to —120° F. to form a solid crystal phase of p-xylene which is separated from the mother liquor. The crystal phase is further treated to recover p-xylene.

U.S.P. 2,541,959. Process of Separating the 3,5-Dimethyl 1-Ethyl Benzene from Other Ethyl Xylenes. W. E. Elwell to California Research Corporation.

A mixture of ethyl xylenes containing the 3,5-dimethyl 1-ethyl benzene is sulfonated under conditions adapted to effect substantially complete sulfonation of the ethyl benzenes. The reaction product is digested with water at an elevated temperature below 160° C., whereby the sulfonated 3, 5-dimethyl 1-ethyl benzene is selectively hydrolyzed and thus separated from the mixture.

U.S.P. 2,541,990-542,013. Processes for Breaking Petroleum Emulsions. M. DeGroote and B. Keiser to Petrolite Corporation, Ltd.

Details of processes are claimed for breaking petroleum emulsions of the water-in-oil type by the action of a demulsifier including hydrophile synthetic products which are oxyalkylation products of various organic compounds, particularly of those of a certain alpha-beta alkylene oxide and of a fusible and soluble phenol-aldehyde resin, combined.

U.S.P. 2,542,187. Method of Separating Selected Constituents from Gases. W. F. Fulton to Warren Petroleum Corporation.

In the separation of selected constituents from a gaseous medium, e.g. of N-heptane from methylcyclohexane, by a hydrocarbon stripping liquid, 0.5-8 percent of glaurin are incorporated in this liquid to increase the absorption rate of the liquid.

U.S.P. 2,542,520. Ethylene Extraction. H. J. Hibshman to Standard Oil Development Company.

Details are claimed of a process for separating ethylene from a mixture of saturated and unsaturated hydrocarbons containing methane, ethylene, ethane, propane, and propylene by means of a liquid hydrocarbon solvent boiling higher than ethylene, e.g. a naphtha fraction containing 3-8 C hydrocarbons.

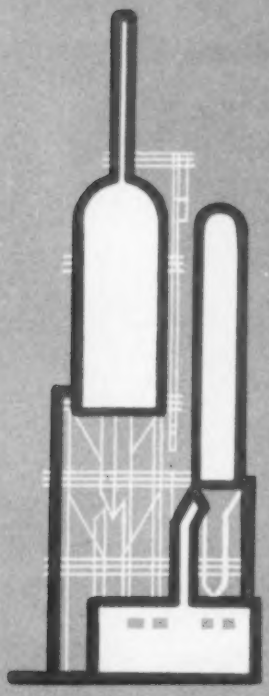
U.S.P. 2,543,223. Processes for Breaking Petroleum Emulsions. C. M. Blair, Jr., to Petrolite Corporation, Ltd.

A special type of an imidazoline salt of an alkylated aromatic monosulfonic acid is used as a demulsifier for water-in-oil petroleum emulsions.

U.S.P. 2,543,242. Apparatus for Treating Crude Petroleum and Other Liquids. F. A. Kent and C. W. Patrick, Midland, Mich.

The construction is claimed of an apparatus for separating liquids of different sp.gs., such as oil and brine. Oil, brine, and other impurities are taken

fluid catalytic cracking



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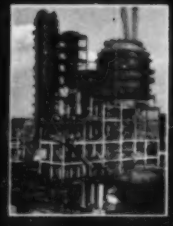

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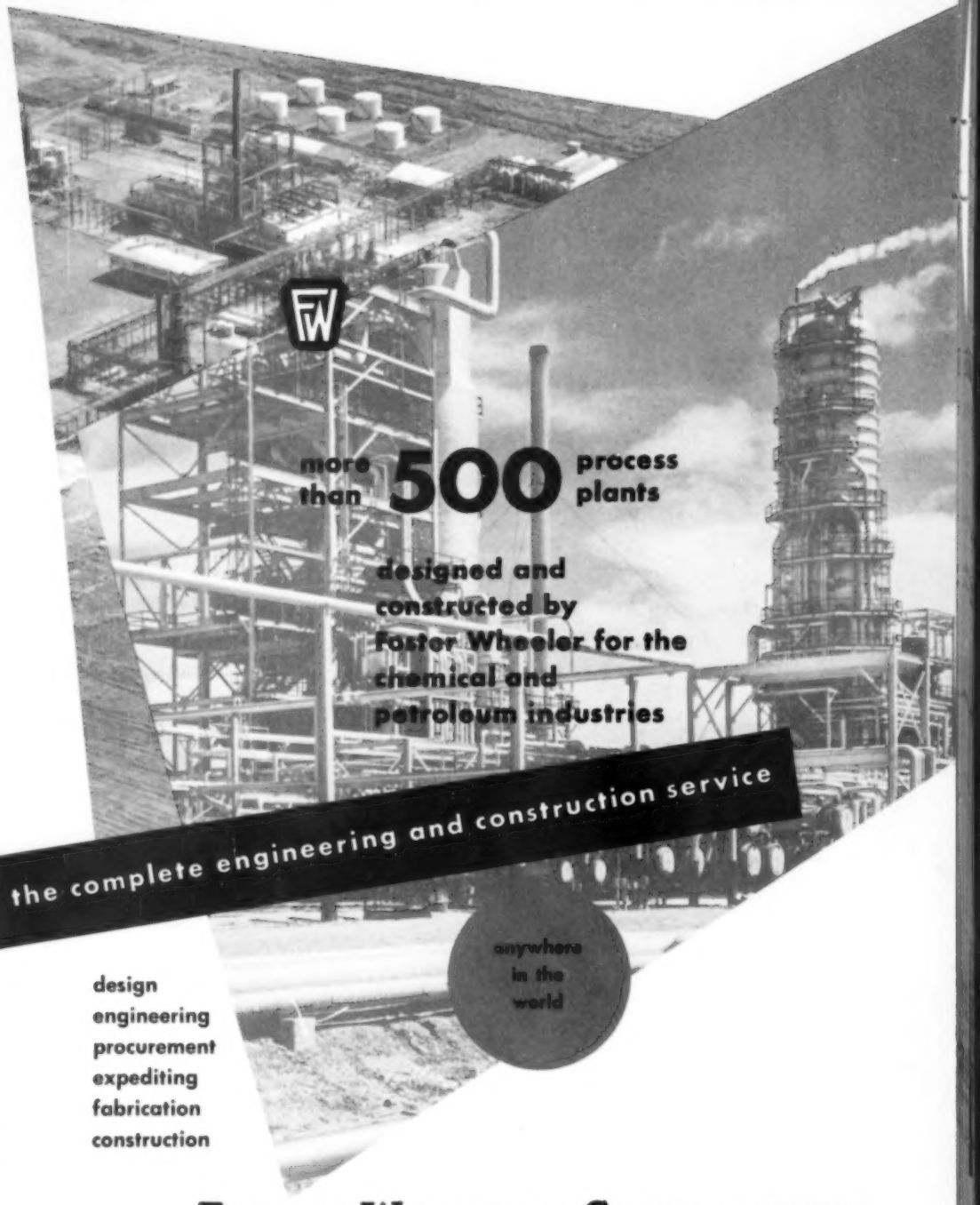

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off from the separator at different levels.

U.S.P. 2,543,286. Process for Separating Hydrocarbons. A. E. Hirschler to Sun Oil Company.

A liquid mixture of hydrocarbons of the same degree of saturation is treated with a granular adsorbent, such as silica gel or activated carbon, at a temperature at which the hydrocarbons exhibit an S-type adsorption isotherm. The mixture is thereby separated into a fraction containing one of the hydrocarbons in relatively purified form and another fraction containing the charge hydrocarbons in a proportion approaching that at which their tendency to be adsorbed is the same. The latter fraction is then treated with the same type of adsorbent at a substantially different temperature for further separation of the hydrocarbons.

U.S.P. 2,543,478. Purification of Hydrocarbons. J. W. Tooke and P. F. Warner to Phillips Petroleum Company.

Acetylenic impurities are removed from butene or a C_3-C_4 aliphatic hydrocarbon mixture by countercurrently contacting the mixture with an acidic aqueous solution of a mercuric salt at a temperature of 140-160° F. and at least atmospheric pressure. A precipitate of a mixture of metallic mercury and mercury compounds is formed. The precipitate is dissolved in HNO_3. The resulting solution is mixed with an aliphatic alcohol having 1-2 C atoms and passed to the contacting zone.

U.S.P. 2,543,487. Composition for Treating Mineral Wool. A. E. Budner, A. F. Buckman, and M. M. Rendall to S. C. Johnson & Son, Inc.

An aqueous emulsion concentrate consisting of a certain type of mineral oil, an emulsifier, and polybutene in special proportions is effective in rendering mineral wool capable of floating on boiling water.

U.S.P. 2,543,489. Process for Breaking Petroleum Emulsions. M. DeGroote and B. Keiser to Petrolite Corporation, Ltd.

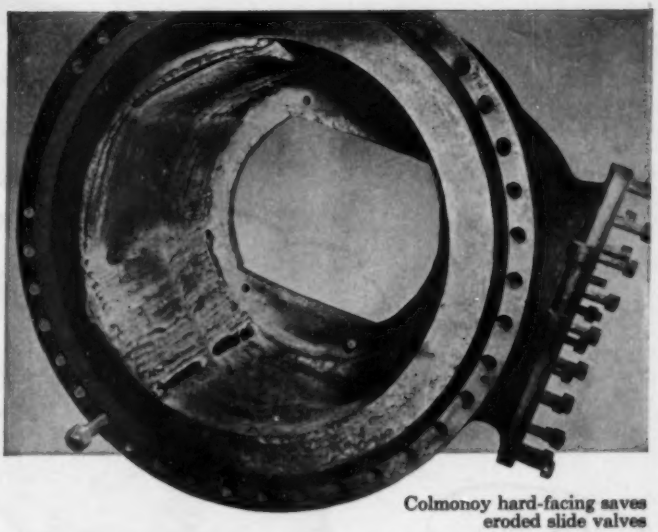
A special type of hydrophile synthetic products is employed as a demulsifier for breaking water-in-oil petroleum emulsions. The synthetic products employed are oxyalkylated tri-nuclear phenolic resins.

U.S.P. 2,543,614. Selective Adsorption of Olefins. J. W. Teter to Sinclair Refining Company.

A homogeneous hydrocarbon mixture containing olefins is contracted with a sulfide of W, Mo, Ni, Co, Fe, or Zn at a temperature of 0-300° F.; the olefins are selectively adsorbed and removed. They are then separated from the adsorbent by desorption.

U.S.P. 2,543,838. Oxygen Removal from Absorption Oils. H. Ernst, Jr., to Standard Oil Development Company.

A first hydrocarbon stream containing oxygen is contacted with an absorption oil under conditions to absorb hydrocarbon. The enriched oil is then contacted with a second hydrocarbon stream free of oxygen under corresponding conditions. The hydrocarbons are then re-



Colmonoy hard-facing saves eroded slide valves

Service Life is Extended 500% with COLMONOY No. 1 Hard-Facing

The catalyst slide valve shown here was the badly eroded property of a large western refinery. The interior wall had suffered severe erosion, to a depth, in some places, of over a quarter inch. The valve gate had lost 1/16" as well. The job for hard-facing: to reclaim and extend service life.

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The slide valve gate was preheated and then maintained at 350-400° F. COLMONOY No. 1 welds fast and easy.

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covered from the oil in an oxygen-free state.

U.S.P. 2,543,995. Treating Hydrocarbon Oils. T. B. Tom to Standard Oil Company (Indiana).

A copper-contaminated hydrocarbon oil, particularly from a sweetening operation, is mixed with an oil immiscible solution of certain types of organo-substituted arsenic acids or mixtures thereof. The treated and thereby stabilized oil is then separated from the solution.

U.S.P. 2,544,214. Apparatus for Gas Separation by Adsorption. C. H. O. Berg to Union Oil Company of California.

The construction is claimed of an apparatus for the separation of a gaseous mixture by means of a moving solid adsorbent, such as charcoal, and for the control and metering of the flow of this adsorbent or other granular material.

U.S.P. 2,544,559. Method for Producing a Low Odor Naphtha. M. P. Matuszak to Phillips Petroleum Company.

A straight run naphtha boiling between 300-550° F. and containing odor-producing compounds is contacted with hydrocarbon effluent from an isoparaffin-olefin alkylation process in the presence of a liquid catalyst, such as HF. The odor producing bodies, particularly the easily alkylatable high-odor bodies are removed. Further details are claimed.

U.S.P. 2,544,564. Method of Preventing Foaming of Aqueous Absorption Liquids When Employed in the Removal of Acid Constituents Present in Gaseous Mixtures. I. A. Peterson and E. S. Palmer, Jr., to Phillips Petroleum Company.

In the removal of acidic constituents, e.g. H_2S, from natural gas and the like by means of an aqueous ethanolamine solution, a solution of stearyl alcohol in isopropyl alcohol is added to the ethanolamine solution to prevent foaming.

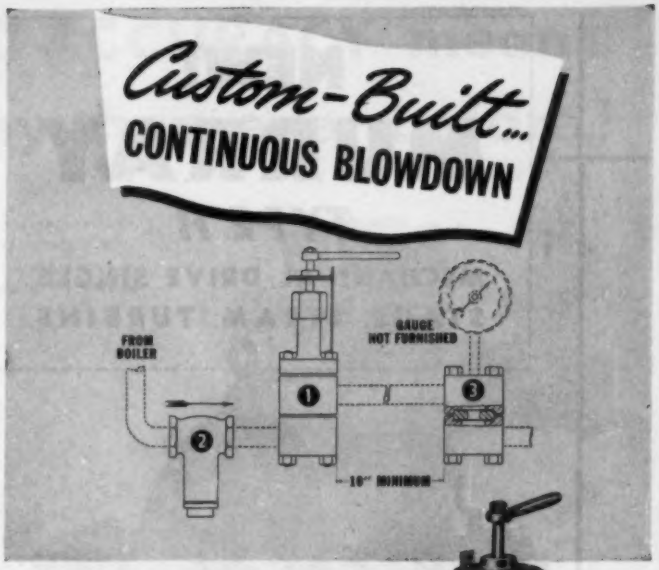
CATALYST PREPARATION, ACTIVATION, AND REGENERATION

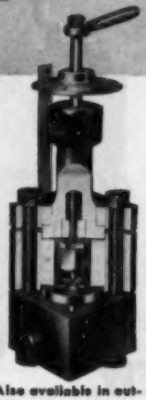
U.S.P. 2,541,109. Method and Apparatus for Preparation of Contact Masses. H. A. Shabaker to Houdry Process Corporation.

Hard strong molded contact masses are produced from molded units of wet workable material by directing drying gases at elevated temperature into engagement with an undivided entire end surface of the unit to effect rapid evaporation and to develop hardness progressively from this surface through the units. Water is added to the unit in quantity sufficient to retard evaporation and setting in the portion of the unit opposite the treated end surface until dehydration and setting has progressed through the unit.

U.S.P. 2,541,654. Method of Regenerating Hydrocarbon Synthesis Catalyst. W. H. Jones, F. M. Long, and R. W. Krebs to Standard Oil Development Company.

Spent iron-containing hydrocarbon synthesis catalyst is regenerated by heating it to 900-1400° F. in the presence





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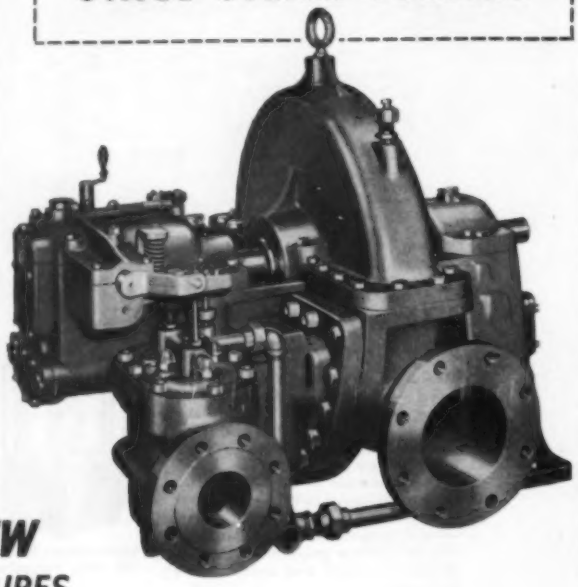

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of an added inert gas to reduce the carbon and oxygen concentration build up on the catalyst during the synthesis operation. The process is particularly useful for the regeneration of synthetic ammonia iron catalysts.

U.S.P. 2,541,671. Preparation of a Fluid Catalyst for Hydrocarbon Synthesis. M. A. Segura, D. R. McAdams, and W. E. Spicer to Standard Oil Development Company.

A reduced precipitated iron oxide mass is sintered in an oxidizing atmosphere at a temperature of 1200-1600° F. The sintered material is ground to a fluidizable particle size and then reduced at a temperature of 800-1500° F. Potassium carbonate can be incorporated in the precipitated iron oxide. This catalyst combines high activity and long life with highest utility for fluid hydrocarbon synthesis.

U.S.P. 2,541,680. Reactivation of Catalysts Containing Iron. H. G. Vesterdal to Standard Oil Development Company.

The reactivation is claimed of an iron oxide catalyst containing a potassium compound promoter and used in dehydrogenating butene or ethyl benzene. The catalyst deactivated by repeated regeneration is treated with CO at a temperature of 200-800° F. and subsequently heated to above 1000° F. in the presence of steam.

U.S.P. 2,542,558. Regeneration of a Cobalt Oxo Synthesis Catalyst. E. A. Naragon, A. J. Millendorf, and J. H. Vergilio to The Texas Company.

Cobalt catalysts spent in the conversion of olefins, CO and H_2 into carbonylic products are regenerated with steam at a temperature of 600-1000° F. for at least four hours.

U.S.P. 2,542,610 Friedel-Crafts Double Salt Catalyst. D. W. Young to Standard Oil Development Company.

A catalyst, particularly suited for polymerizations, consists of a double salt of a Friedel-Crafts active metal halide with a Friedel-Crafts active metal oxy halide, e.g. of AlB_3 and AloBr.

U.S.P. 2,542,813. Manufacture of Catalyst. S. B. Heath to The Dow Chemical Company.

Details are claimed of a method for preparing a calcium nickel phosphate material effective as a catalyst for the dehydrogenation of butylene to form butadiene.

U.S.P. 2,543,069. Art of Preparing Gel. H. A. Shabaker to Houdry Process Corporation.

Gel-forming liquids are passed to a zone where they are mixed with each other. The resulting mixture is passed downwardly at least partly by gravity until it engages and in drop formation floats on the surface of a supporting liquid of higher sp.g. and immiscible with the gel-forming mixture. It is maintained continuously in drop formation and in floating relation on said surface while setting to hydrogel thereon.

U.S.P. 2,543,132. Catalyst Manufacture and Apparatus Therefor. H. A. Shabaker to Houdry Process Corporation.

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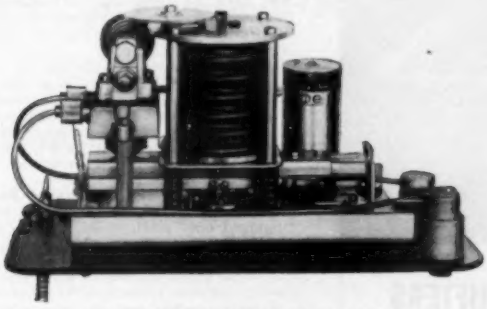

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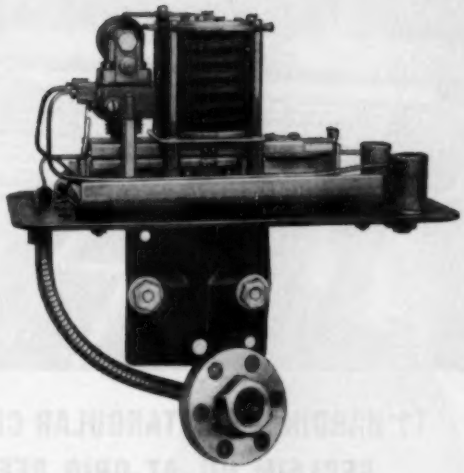

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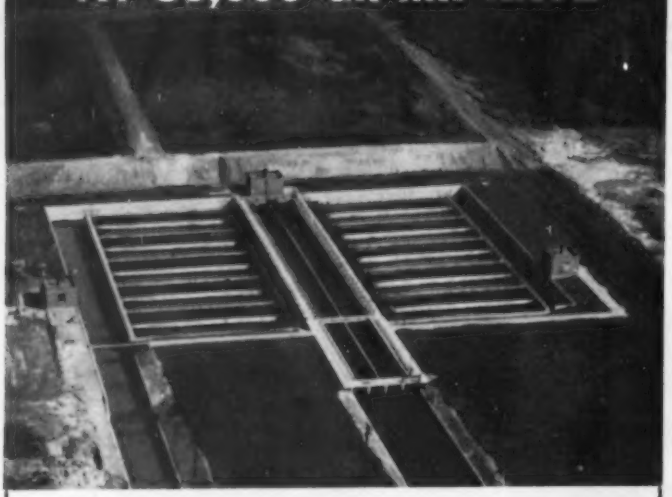

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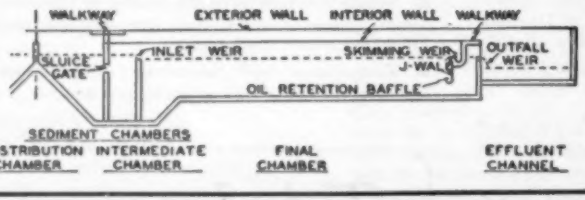

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Individual drops of a gel-forming liquid are successively introduced into an inclined groove and then into a liquid immiscible with the gel-forming liquid which then sets to hydrogel. Individual drops of other liquid are successively passed into the inclined groove alternately with individual drops of the gel-forming liquid. The drops of other liquid following the drops of gel-forming liquid while passing down the groove inhibit coalescing of several drops of the latter and thus ensure formation of hydrogel beads of equal size.

U.S.P. 2,543,327. Preparation of Reduced Magnetite Synthesis Catalyst. H. G. McGrath and L. C. Rubin to The M. W. Kellogg Company.

Natural magnetite is calcined at a temperature of 1000-1600° F. for at least two hours. The product is pulverized to the desired size and then reduced with hydrogen at elevated temperature. The catalyst obtained is particularly useful for the Fischer-Tropsch synthesis.

U.S.P. 2,543,863. Fluidized Catalyst Regeneration Process. H. Z. Martin to Standard Oil Development Company.

In a method for separating regenerated catalyst from the regenerating gases, these gases are treated after separation of the bulk of catalyst by a spray of water to scrub out the remaining catalyst fines. The aqueous suspension of catalyst particles is further treated to regain dry catalyst therefrom.

U.S.P. 2,544,574. Catalyst Regeneration. S. W. Walker and A. G. Eickmeyer to Stanolind Oil and Gas Company.

Spent finely divided iron catalyst containing iron carbide is regenerated by contacting it with a mixture of hydrogen and 5-40 percent water vapor at a temperature of 600-1300° F. for 2-20 hours. The carbonaceous deposits are removed without material oxidation of the catalyst.

CRACKING AND REFORMING

U.S.P. 2,541,662. Device for Controlling Flow of Solids in a Powdered Solid and Gas Contacting Operation. J. S. Palmer to Standard Oil Development Company.

The construction is claimed of a device for suspending finely divided solid catalysts in a catalytic operation, e.g. cracking of hydrocarbons. The flow of catalyst from the reaction zone or regenerating zone is controlled independent of mechanical mechanisms by maintaining a head of catalyst on a vertical conduit leading into a transverse conduit and flowing the catalyst from the vertical conduit as a dense phase into a disperse phase in the transverse conduit.

U.S.P. 2,541,693. Production of Lower Olefins. L. K. Frevel and J. J. Grebe to The Dow Chemical Company.

In a continuous process of making lower olefins by cracking a hydrocarbon stream above 1300° F. a procedure is claimed for quenching the hot cracked gas and removing acetylene therefrom. Cool moving refractory pebbles are employed as the quenching means which have deposited thereon an oxide of Cu

ANACONDA Arsenical Admiralty—

a practical solution to tube dezincification

What causes dezincification?

Metallurgical research indicates a number of conditions causing dezincification of condenser and heat exchanger tubes:

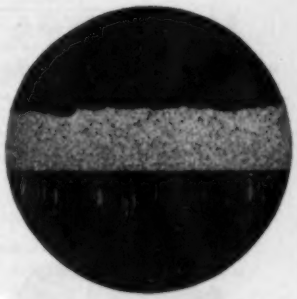
LAYER TYPE dezincification tends to be the result of a critical degree of acidity of the cooling water.

PLUG TYPE dezincification is more apt to occur where the cooling water is neutral or alkaline.

LOW WATER VELOCITY may accelerate the loss of zinc by failing to wash away copper salt solutions, thereby permitting redeposition of copper.

HIGH COOLING WATER TEMPERATURES hasten over-all corrosion reactions and seem to favor the electrochemical process causing redeposition of copper.

LOW OXYGEN CONTENT of cooling water is also considered a factor in accelerating the redeposition of copper. 51127



Longitudinal section through Arsenical Admiralty tube. No evidence of dezincification. Upper surface is waterside. 7x.

Longitudinal section through wall of non-Arsenical Admiralty tube showing dezincification plug starting from waterside (upper surface). 7x.

Arsenic as an Inhibitor

Laboratory studies and field installations have clearly indicated the effectiveness of small quantities of arsenic in Admiralty and other copper alloys as an inhibitor to dezincification. The inhibiting action of arsenic, as well as of other inhibitors, is not well understood. One theory holds that the inhibitor covers anodic areas to prevent initial selective corrosion; another states that it forms a film of an electropotential equal to that of the copper to prevent the copper redepositing.

For Technical Counsel

The files of Anaconda's Technical Department and the experience of its engineers cover the case histories of condenser and heat exchanger tubes operating under the widest variety of conditions. These are freely available to you to help you select the right alloy for your installation. The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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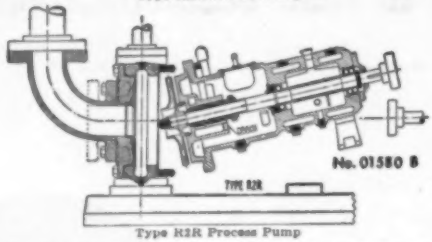

Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R. Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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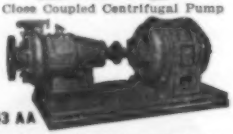
CENTRIFUGAL and RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

3510

Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



4043 AA

Pedestal Mounted Centrifugal Pump

3833

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump

4728

Double Pedestal Bearing Centrifugal Pump

3556

Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

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Patents

or Fe, or mixtures thereof. Acetylene is decomposed thereby while the pebbles become heated and coated with carbon.

U.S.P. 2,541,795. Catalytic Cracking of Hydrocarbons. G. M. Verley to Sinclair Refining Company.

In a process for producing lighter, lower boiling hydrocarbons by cracking heavier hydrocarbons containing straight and branched chain paraffins in the presence of a solid catalyst, the hydrocarbons remaining on the spent catalyst after partial stripping are partially oxidized by air in a certain ratio at a temperature of 300-750° F. The thus partially oxidized hydrocarbons are then mixed with an intermediate fraction of the cracking effluent containing straight chain paraffins, and this mixture is cracked again to obtain on fractionation of the cooled effuent additional low-boiling hydrocarbons.

U.S.P. 2,542,471. Removal of Peroxides from Cracked Gasoline by Catalytic Hydrogenation. R. C. Brandon to Standard Oil Development Company.

Unstable oxygen-containing organic compounds in cracked gasoline containing olefins are selectively reduced by reacting them with hydrogen at a temperature below 400° F. in the presence of compact catalyst of a synthetic silica or alumina gel carrier with ultra microscopic pores and 0.1-10 percent of a colloidal Pt or Pd metal. No significant change in the olefin characteristics of the cracked gasoline occurs.

U.S.P. 2,543,884. Process for Cracking and Coking Heavy Hydrocarbons. J. Weikart to Standard Oil Development Company.

Heavy residual hydrocarbon oils are contacted with hot finely divided coke at a temperature above 900° F. for a relaitvely short time to cause only mild cracking and vaporization of the less refractory portions of the oils. The coke particles and unvaporized portion of the oils are then treated in a coking zone at a temperature of at least 850° F. for a substantially longer period of time to convert the oil into vapors and coke. The hydrocarbon vapors from both treatments and a high grade coke are recovered.

ALKYLATION

U.S.P. 2,541,044. Catalytic Alkylation. J. P. Daugherty to Houdry Process Corporation.

An alkylatable hydrocarbon and an alkyl supplying hydrocarbon are reacted in the presence of a solid adsorptive alkylation catalyst under alkylation conditions. The flow of alkyl supplying hydrocarbon to the reaction zone is periodically interrupted at predetermined intervals of on-stream time, while the flow of the alkylatable material is continued under liquid phase conditions and at elevated alkylation temperature for a length of time sufficient to effect restoration of the catalyst activity.

U.S.P. 2,541,882. Alkylation of Polynuclear Aromatic Hydrocarbons. R. J. Moore to Shell Development Company.

An alkyl substituted polynuclear aromatic hydrocarbon, such as amyl naphthalene, is produced by reacting a poly-

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TANK SUCTION HEATER INSTALLATION

The shell is open at the inside end. The oil moves across the heating tubes as it passes through the shell to the suction connection outside the tank.

In Bulk Oil Terminals and Refineries the world over Paracoil Tank Suction Oil Heaters are licking the problem of economically preheating heavy viscous oils to permit their withdrawal from storage tanks. They are also preheating the lighter grades of fuel oils to their proper delivery temperatures to avoid the costly volume losses incurred when such oils are sold at low temperatures.

WITH PARACOIL TANK SUCTION OIL HEATERS

- **You Heat Only The Oil That Is Being Withdrawn From The Tank.** (Thus radiation losses resulting from heating entire tank contents are eliminated.)
- **Overall Steam Consumption And Heating Costs Are Held To A Minimum.**
- **Heater Tube Bundle Can Be Withdrawn For Inspection And Cleaning.** Breaking of oil suction line not necessary.
- **All Piping Connections And Gaskets Are Outside The Tank.**
- **U-Tube Design Permits Free Expansion And Contraction Of Tube Bundle.** Either high or low pressure steam can be used as the heating medium.

SPEED UP DELIVERIES AND CUT OIL VOLUME LOSSES WITH PARACOIL TANK SUCTION HEATERS

Prompt Shipments!
Our extensive stocks of tubing and pipe enable us to make quick deliveries to meet your immediate requirements.
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In addition to the Paracoil Tank Suction Heaters, we also design and fabricate Line Type Discharge Heaters of any capacity. Illustrated is a Paracoil Straight Tube Type Fuel Oil Heater for bulk station service—capacity 2,000 gallons per minute, No. 6 oil, 100°F to 160°F, steam at 15 psig. Weight 12 tons.

DAVIS ENGINEERING CORPORATION
1060 East Grand Street, ELIZABETH 4, NEW JERSEY
30 Rockefeller Plaza, NEW YORK 20, N. Y.

Patents

nuclear ar. hydrocarbon with an olefin at a temperature of 10-150° C. in the presence of a molar excess of a mononuclear aromatic hydrocarbon, and a preformed aliphatic hydrocarbon-aluminum halide complex presaturated with a mononuclear aromatic hydrocarbon and containing no free aluminum halide.

U.S.P. 2,542,190. Process for Alkylation of Aromatics. M. H. Gorin and E. Gorin to Socony-Vacuum Oil Company, Inc.

Aromatic hydrocarbons and alcohols are contacted in the presence of a composite catalyst comprising precipitated silica and alumina zirconia or thoria, for not more than 15 minutes. Alkylated aromatic hydrocarbons are obtained.

U.S.P. 2,542,927. Method of Operating an HF Alkylation Unit. C. S. Kelley to Phillips Petroleum Company.

Details are claimed for the alkylation of a low boling isoparaffin or the like with an alkylating agent in the presence of a HF catalyst.

U.S.P. 2,544,552. Production of Drying Oils by Treatment of Acid-Soluble Oils with Hydrofluoric Acid. P. H. Carnell to Phillips Petroleum Company.

An alkylate product obtained in the alkylation of an isoparaffin and an olefin in the presence of HF is separated from a HF-phase containing acid-soluble oil as a by-product of the alkylation. This acid-soluble oil is separated and contacted as a liquid with HF under special conditions of temperature, pressure and time. A hydrocarbon phase and an acid phase are formed. The latter contains an unsaturated rapid drying oil which is recovered as product of the process.

POLYMERIZATION AND CONVERSION

U.S.P. 2,541,077. Method and Apparatus for Contacting Subdivided Solid Particles with a Fluid Reactant Stream. F. W. Leffer to Universal Oil Products Company.

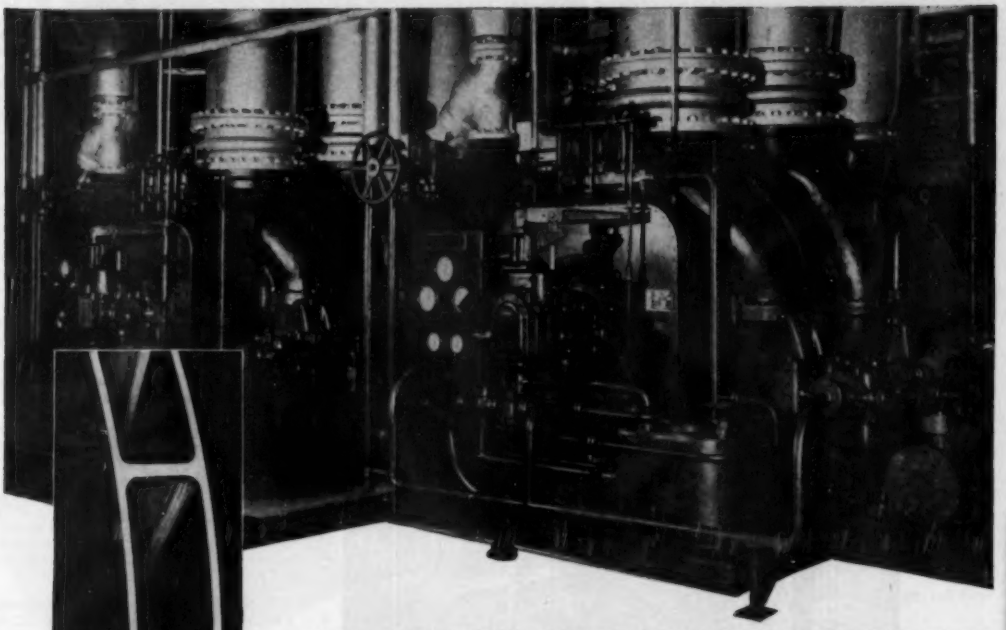
Details are claimed of a continuous process for the conversion of hydrocarbons at elevated temperature in the presence of solid contact material particles. The conversion is effected in two stages and the contact material is maintained in a continuous cyclic flow through the unit. The reactant stream contacts used or partially cooled contact material in the first stage and freshly reconditioned or reactivated contact material at increased temperature in the second stage.

U.S.P. 2,541,186. Catalytic Conversion of Hydrocarbons. N. K. Anderson to Universal Oil Products Company.

Details are claimed of a process for the conversion of fluid reactants, particularly hydrocarbons, in the presence of subdivided solid catalyst. Contaminated catalyst particles are passed from the reaction zone laterally through a partition with vertically spaced openings into a stripping zone where they are contacted with a stripping medium.

U.S.P. 2,541,548. Pebble Heating Chamber for Pebble Heaters. S. P. Robin-

Big blowers for a vital job



WELDED IMPELLERS are one of the many reasons why Elliott blowers are getting ever-increasing acceptance for process work. Note the smooth contours, heavy blades, and generally rugged construction (as compared to conventional riveted impellers). Each impeller is a completely homogeneous unit and can be made of any weldable material having reasonable mechanical strength.

"CAT CRACKING" CALLS FOR ELLIOTT DEPENDABILITY

for the unfailing supply of the large volumes of air needed to convey and reactivate the catalyst. Elliott blower units are now operating in many refineries, continuously serving the catalytic process. The two large Elliott blowers shown above are typical, supplying 55,200 cfm of air at 18 psig. Each blower is driven by a 2200-hp Elliott steam turbine exhausting upward to an Elliott surface condenser.

Continuity of operation is an essential of "cat" crackers and other process requirements—an emergency shutdown may result in serious damage to equipment and prolonged loss of production. Elliott units have been designed with this requirement in mind and operating records prove conclusively that they have the rugged dependability necessary to meet the exacting requirements. Contact your nearest Elliott representative for details.

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P-1089

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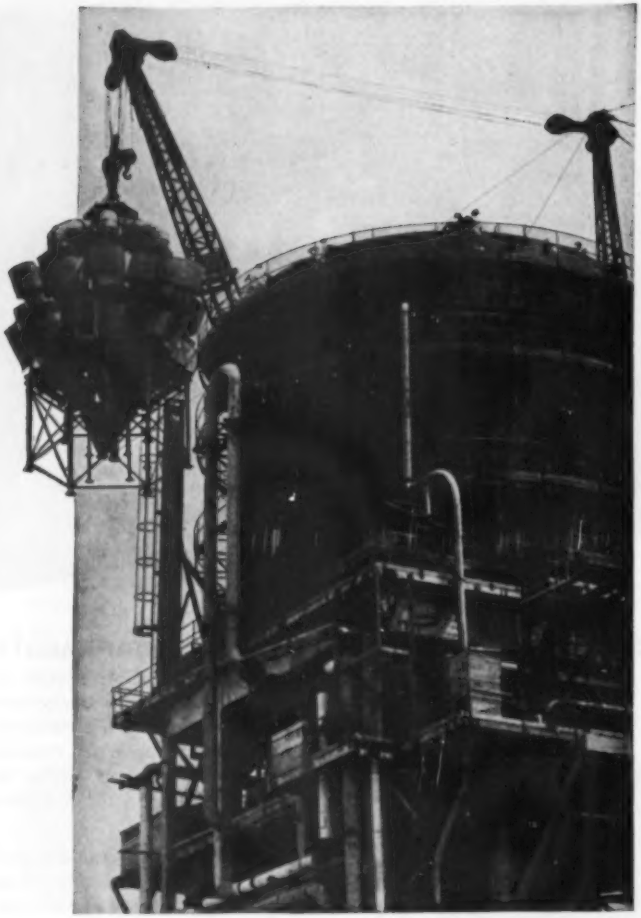
The heart of the "cat" cracker

BUELL 'GOES TO THE TOP'

in catalyst recovery



In fluid or thermofor catalytic cracking Buell recovery systems have demonstrated continuous high-efficiency performance in all the major refineries. Design information is available on the latest multi-stage collectors. Buell Engineering Company, 70 Pine Street, Suite 5070, New York 5, N. Y.

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DUST COLLECTION

MANUFACTURING IN UNITED STATES AND CANADA FOR SHIPMENT THROUGHOUT NORTH AND SOUTH AMERICA

Patents

son to Phillips Petroleum Company.

The construction is claimed of an apparatus for heating pebbles in a flowing stream.

U.S.P. 2,541,635. Recovering Catalyst in Oil Vapors. M. W. Boyer to Standard Oil Development Company.

Entrained catalyst contained in the vaporous reaction products of a hydrocarbon conversion process is treated in a quenching and scrubbing zone with an oil to condense the highest boiling constituents of the reaction products and to wash out entrained catalyst. The uncondensed vapors are further treated. A concentrated catalyst slurry is withdrawn from the condensed highest boiling constituents after settling.

U.S.P. 2,541,801. Stripping of Oil from Spent Cracking Catalyst. M. J. Wilcox to Sinclair Refining Company.

Details are claimed of a process and apparatus for stripping a finely divided spent catalyst from entrained oil from a hydrocarbon conversion reaction. The stripping is effected in a plurality of stages in which the catalyst is repeatedly suspended in the stripping medium, e.g. steam.

U.S.P. 2,542,459. Polymerization Process. J. H. Bannon to Standard Oil Development Company.

A major amount of an isoolefin, e.g. isobutylene, and a minor amount of a multiolefin with 4-12 C atoms, e.g. isoprene, are mixed with a halo-substituted alkane diluent and copolymerized at a temperature of —40° to —127° C. in the presence of a solution of a Friedel-Crafts catalyst in a haloalkane solvent. The resulting slurry is filtered, and the filter residue is directly extruded.

U.S.P. 2,542,516. Treatment of Naphtha Containing Oxygenated Bodies. R. L. Heinrich to Standard Oil Development Company.

A naphtha containing olefins and contaminated with oxygenated organic compounds is contacted with a Friedel-Crafts catalyst in the presence of a small amount of water at a temperature no greater than 150° F. A hydrocarbon fraction separated from the reaction product formed is polymerized at a temperature of 75-250° F. in the presence of a Friedel-Crafts catalyst. The polymer formed has lubricating oil qualities.

U.S.P. 2,542,559. Treatment of Isobutylene Polymer Slurry to Enlarge Particle Size. J. F. Nelson and B. R. Tegge to Standard Oil Development Company.

A major proportion of isobutylene is copolymerized with a minor proportion of a multiolefin of 4-12 C atoms at a temperature of —10° to —127° C. in the presence of a Friedel-Crafts catalyst. Details of the process are claimed.

U.S.P. 2,542,587. Vibrating Means for Fluidized Catalyst Reactors. R. B. Smith to Sinclair Refining Company.

The construction is claimed of an apparatus adapted to the fluid catalyst conversion of hydrocarbons. It is provided with mechanical means for imparting rapid, vibratory motion to vertical shafts provided with outwardly extending fins.

U.S.P. 2,542,887. Apparatus for Pyrolytic Conversion of Hydrocarbons. K. M. Watson to Sinclair Refining Company.

Looking for a stud to combat premature fatigue failure? . . . One which really stays on the job, even under excessive strain and vibration? Use the Bethlehem Continuous-Thread Tap-End Stud.

The Bethlehem Continuous-Thread Tap-End Stud fights fatigue failure because it has no point of thread-runout. Thus the stress concentrations encountered in difficult bolting jobs are distributed over the effective working length of the stud.

Moreover, this husky stud carries two types of threads. Its chamfered tap-end is threaded to Class 5 fit, while the rounded nut-end is threaded to either Class 2, 3 or 7 fit. Yet so skillfully are these threads blended that the point of change is undetectable.

The Bethlehem Continuous-Thread Tap-End Stud is made from carbon or alloy steel, and can be furnished heat-treated, if desired.

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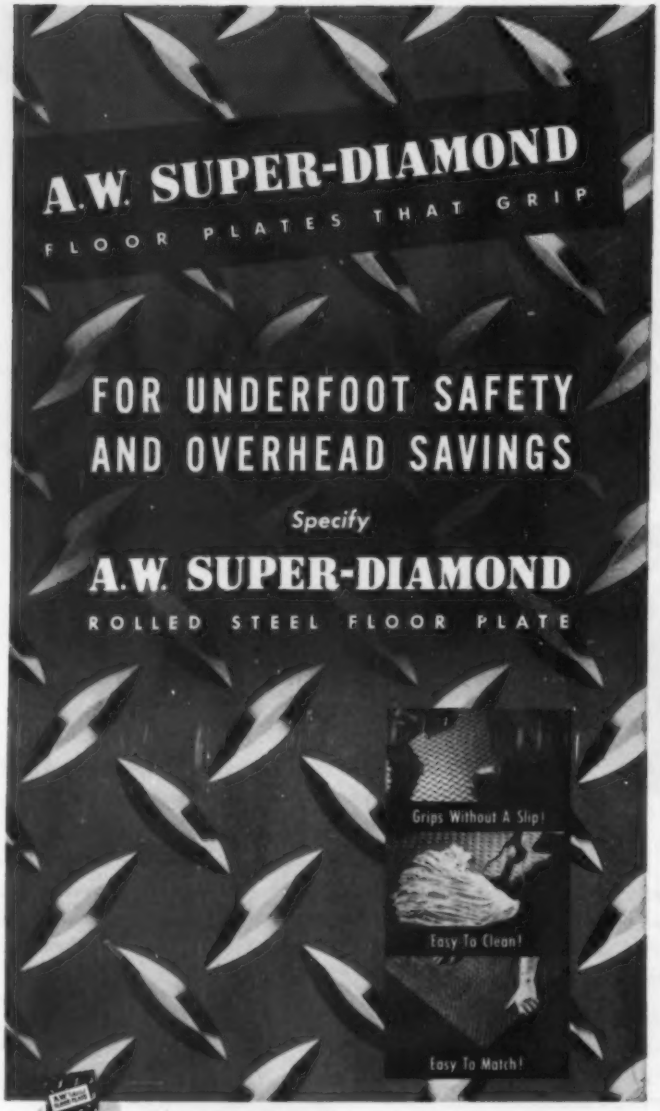

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Patents

The construction is claimed of an apparatus for the pyrolytic conversion of hydrocarbons. The use of troublesome mechanical elevator means is eliminated and the customary long seal leg at the bottom of the reactor is made unnecessary.

U.S.P. 2,542,970. Refining of Cracked Naphthas by Selective Hydrogenation. M. C. K. Jones to Standard Oil Development Company.

Diolefins contained in a low boiling fraction of cracked petroleum naphtha distillate are passed in vapor phase with excess hydrogen at a temperature of 200-400° F. over a catalyst consisting of 0.1-10 percent of Pt or Pd on alumina. Sulfur components of a heavy fraction of the cracked naphtha are reduced and unsaturated components of this fraction are saturated by hydrogenation under corresponding conditions with the same type of catalyst. Products of the treated light and heavy fractions are blended to obtain a fuel blend of improved stability and antiknock performance.

U.S.P. 2,543,005. Method for Conducting High-Temperature Conversions. L. P. Evans to Socony-Vacuum Oil Company, Inc.

Gaseous hydrocarbons are subjected to endothermic conversions to form gaseous hydrocarbon products which are unstable at the elevated reaction temperatures. The gaseous feed is preheated to a temperature of about 300° F. and then passed through a confined reaction zone which is maintained at reaction temperature by electric heating. The gaseous reaction products are partially quenched below the reaction temperature but within 300° F. by a liquid medium and then pass through a cooler moving bed of particle-form refractive contact material to quench the products to a temperature at which they are stable. The contact material heated in this quenching zone to a temperature within 300° F. but below reaction temperature later passes through the preheating zone for preheating the hydrocarbon feed and then returns to the quenching zone.

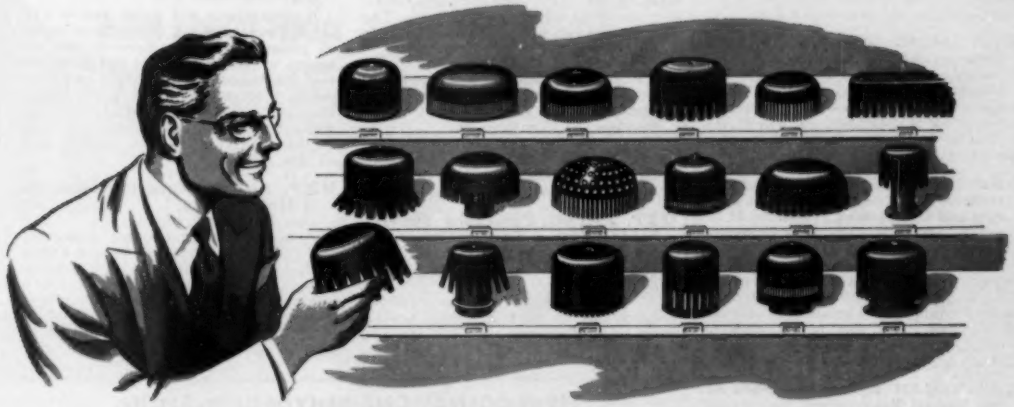
U.S.P. 2,543,016. Catalytic Polymerization. A. V. Grosse to Houdry Process Corporation.

A straight-chain hexadecene or cetene is polymerized under liquid phase conditons at temperatures of 125-350° F. in the presence of an active solid high surface area polymerization catalyst to predominately dimerize the olefins. The process can be combined with the stepwise dimerization in a corresponding manner of olefins with 4 C atoms to form those with 16 C atoms. Successively lower temperatures are maintained in each following dimerization step.

U.S.P. 2,543,070. Hydrocarbon Conversion Apparatus and Process. H. A. Shabaker to Houdry Process Corporation.

In a cyclic hydrocarbon conversion process, catalyst, e.g. acid activated subbentonite clay, is continuously passed through a conversion zone to contact hydrocarbon vapors, spent catalyst is regenerated by burning carbonaceous deposits, and the regenerated catalyst is collected as a bed above the conversion zone and withdrawn from this bed by

If You Don't See What You Want—*Ask for It*



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Any time you are in need of purchasing data on bubble caps may we suggest that you refer to our Bulletin 21 or The Refinery Catalog. In both sources you will find the largest compilation of bubble cap and riser data in print, covering over 200 standard styles furnished by The Pressed Steel Co. Should you not see the style or cap you need we invite you to ask us about your requirements.

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PSC bubble caps are furnished for all methods of tray assembly. Included is the new Le Jons method, which features unprecedented simplicity.

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gravity in a plurality of vertical moving columns to effect uniform distribution of the catalyst. An inert gas is flowed downwardly into these columns to prevent entry of hydrocarbon vapors from the conversion zone. Steam is introduced into the catalyst columns prior to contact of the catalyst with the petroleum stock in the conversion zone.

U.S.P. 2,543,092. Dimerization of Vinyl Cyclohexene. F. J. Bondhus and H. L. Johnson to Sun Oil Company.

Vinylcyclohexene is subjected at a temperature of 50° to —150° C. to the action of an acid catalyst, such as H_2SO_4 or H_3PO_4, for a time sufficient to cause dimerization.

U.S.P. 2,543,306. Polymerization of Styrenes in the Presence of Alcohol Diluents and Unsaturated Peroxides. H. P. Standinger to The Distillers Company, Ltd., Edinburgh.

Styrene or alpha-methyl styrene is heated to a temperature not exceeding 150° C. in the presence of a peroxide catalyst containing the radical of crotonic or cinnamic acid and of an aliphatic alcohol diluent with not more than 5 C atoms, e.g. methanol. A resin is produced.

U.S.P. 2,543,335. Process for Polymerizing Divinyl Benzene and Polyolefinic Esters. B. Phillips, Jr., and W. M. Guattlebaum, Jr., to Union Carbide & Carbon Corporation.

Divinyl benzene is mixed with an organic peroxide catalyst and 50-300 percent of an aliphatic saturated aldehyde with 2-8 C atoms. An ungelled fusible polymer is formed by heating the mixture.

U.S.P. 2,543,742. Method for High-Temperature Conversion of Gaseous Hydrocarbons. L. P. Evans to Socony-Vacuum Oil Company, Inc.

Details are claimed of a process for the continuous conversion of gaseous hydrocarbons to form gaseous products unstable at the reaction temperature, e.g. acetylene containing products. The process is related to that of U.S.P. 2,543,005.

U.S.P. 2,543,743. Method and Apparatus for High-Temperature Hydrocarbon Conversion. L. P. Evans to Socony-Vacuum Oil Company, Inc.

This process for conducting endothermic conversions of gaseous hydrocarbons is closely related to those of U.S.P. 2,543,005 and 2,543,742.

U.S.P. 2,543,845. Plasticizing Synthetic Rubber With a Reaction Product of An Alkyl Mercaptan and Said Rubber. C. F. Fryling to Phillips Petroleum Company.

A conjugated diolefin is emulsion polymerized to form a latex. A separated minor portion of this latex is reacted in the presence of an oxidizing agent with a certain amount of an alkyl mercaptan having not more than 16 C atoms. The resulting product is combined with the major, untreated latex portion. On coagulation, a plasticized rubber-like material is obtained from the mixture.

U.S.P. 2,544,188. Process for the Manufacture of Carburetted Water Gas and Like Gases. M. Steinschlaeger, London.

Hydrocarbons and steam and/or CO_2 are introduced into a regenerator heated to promote recation between the reagents to form water gas and to ensure that the water gas discharges at a temperature of at least 1100° C. Hydrocarbons are introduced into this water gas while still at this temperature to cause cracking due only to the sensible heat of this gas.

U.S.P. 2,544,350. Catalytic Conversion of Hydrocarbons. L. E. Olson to Sinclair Refining Company.

A process is claimed for converting heavier hydrocarbons to lighter hydrocarbons by cracking the hydrocarbon vapors mixed with anhydrous $AlCl_3$ in the presence of CO in an amount sufficient to lower the partial pressure of the $AlCl_3$ sufficient to effect its vaporization under the prevailing conditions.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,541,229. Catalytic Hydrogenolysis of Heavy Residual Oils. H. W. Flemming to Phillips Petroleum Company.

Heavy residual oils are passed downward through a reactor in contact with a catalyst comprising an upper layer of molybdenum oxide on alumina and a lower layer of molybdenum oxide on silica-alumina at a temperature of 825-910° F., and a hydrogen pressure of 2000-5000 psi. Improved gasoline and diesel fuel are produced by this hydrogenolysis operation.

U.S.P. 2,541,237. Hydrogenolysis Process for the Production of Gasoline and a Gas Oil from Residual Oils. L. B. Goodson to Phillips Petroleum Company.

Details are claimed of a process for catalytic hydrogenolysis of refinery residual oils to manufacture gasoline and a good grade gas oil therefrom. The process is related to that of U.S.P. 2,541,229.

U.S.P. 2,541,317. Hydrogenolysis Process for the Production of Gasoline and Diesel Oil from Petroleum Residue Stocks. R. T. Wilson to Phillips Petroleum Company.

The process claimed in detail makes use of the same combination of catalysts as that of U.S.P. 2,541,229 under similar conditions of temperature and pressure.

U.S.P. 2,541,663. Catalyst for the Synthesis of Hydrocarbons. J. A. Pierce and R. W. Richardson to Standard Oil Development Company.

In a Fischer-Tropsch hydrocarbon synthesis process a fluidized catalyst is employed which essentially consists of a bimetallic couple of Al and Fe.

U.S.P. 2,541,677. Hydrocarbon Synthesis. S. D. Summerford and F. J. Buchmann to Standard Oil Development Company.

Versatile Top Entering Mixer by Eastern
Versatile! Series C Vertical Mixers do big mixing jobs quickly and thoroughly. Their power range is from ¼ to 15 H.P. at standard speeds of 1725, 1140, 420, and 280 R.P.M. Standard NEMA ball-bearing type motor is furnished. Stuffing box is separate component and can be specified in any alloy for low original cost. Write our engineers about your mixing problem. Their service is without obligation.
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A simple process for the conversion of waste hydrogen sulfide to pure elemental sulfur

The availability of sulfur is rapidly becoming critical to the refining industry. First pinch was evident when sulfur and sulfuric acid were placed under allocation control by National Production Authority.

Primary cause of sulfur allocation is a gradual depletion of known deposits. Secondary cause is the great demand for sulfur in the manufacture of vital defense program materials. Mined sulfur is the normal source for such materials. The refiner, however, has in most cases his *own* potential source of sulfur.

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The refiner's answer is the Mathieson Process for converting into sulfur the waste hydrogen sulfide recovered from sour petroleum gases. This simple process—available through The Fluor Corporation, Ltd.—accomplishes *two* important purposes:

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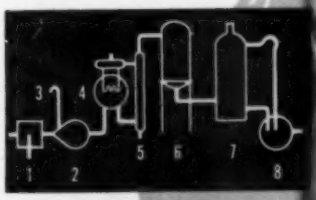
2. *Conserves for national defense* by contributing to the over-all National Defense Program in helping to conserve a critical commodity.



THE MATHIESON SULFUR RECOVERY PROCESS Hydrogen sulfide, recovered from a sour gas stream, is partially burned with air—cooling follows with steam generated being utilized for power. Combustion gases are then passed through a catalyst tower to form sulfur and water vapor. Elemental sulfur product is condensed in a wash tower by direct contact with cooled liquid sulfur. The result is pure commercial sulfur—ready for sale or for conversion into sulfuric acid.

1—TREATING PLANT, 2—REACTOR FURNACE, 3—AIR INTAKE, 4—WASTE HEAT BOILER, 5—ECONOMIZER, 6—CATALYTIC CONVERTER, 7—SULFUR WASH TOWER, 8—RECIRCULATING SUMP

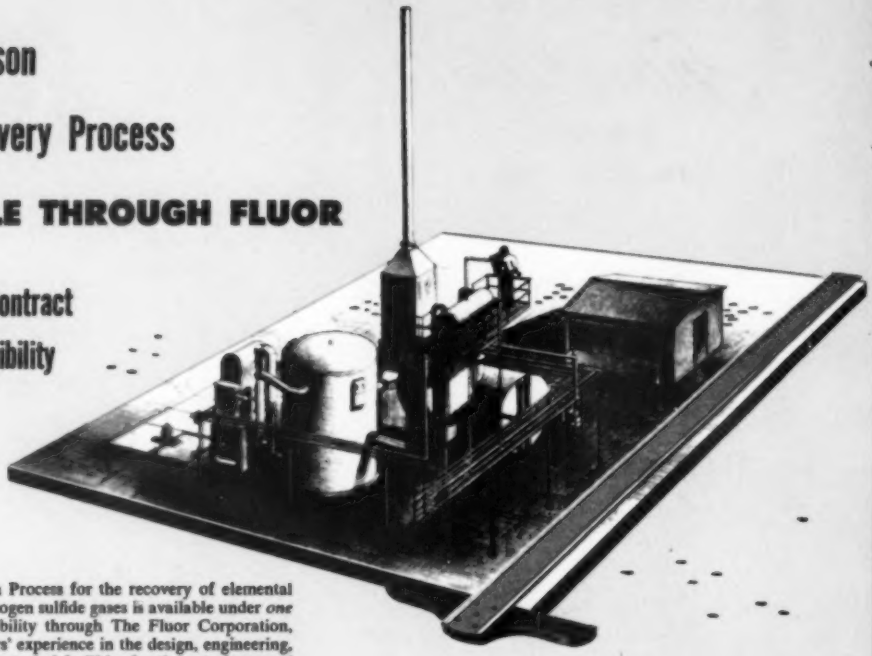
See Reverse Side

The Mathieson

Sulfur Recovery Process

AVAILABLE THROUGH FLUOR

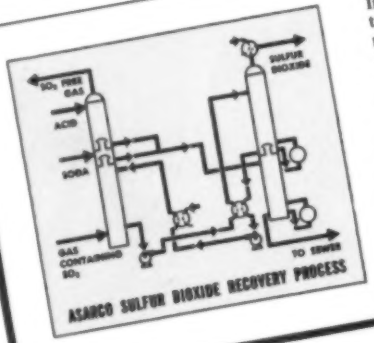
- Under ONE Contract
- ONE Responsibility



The proven Mathieson Process for the recovery of elemental sulfur from waste hydrogen sulfide gases is available under *one* contract, *one* responsibility through The Fluor Corporation, Ltd. With over 30 years' experience in the design, engineering, and construction of plants and facilities for the petroleum and chemical industries, Fluor possesses the background, the skilled personnel, and the know-how essential for the practical interpretation of the Mathieson Process into *your particular* sulfur recovery program.

Fluor is in a position to make economic studies covering every phase of proposed sulfur recovery installations—initial investment, operating costs, and returns to the investor.

A process for the recovery of Sulfur Dioxide is also available through FLUOR



ASARCO SULFUR DIOXIDE RECOVERY PROCESS

In line with Fluor's expanding activity in the fields of gas treating and sulfur recovery, arrangements have been made with the American Smelting and Refining Company (ASARCO) for Fluor to design, engineer and construct sulfur dioxide recovery plants using the ASARCO Process. Fluor's investigations have shown this process to be the most suitable of any available for the removal and recovery of pure sulfur dioxide from stack gases. In the application of the process, the gas is scrubbed with dimethylaniline which is then fed to a stripping column for sulfur dioxide recovery in a cyclic process. The resulting sulfur dioxide product may be dehydrated and liquefied for sale as liquid SO_2 or fed directly to an acid or sulfur plant.

All details including first studies are available through The Fluor Corporation, Ltd., and the American Smelting and Refining Company.

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Patents

A feed gas containing H_2 and CO is contacted with a fluidized bed of powdered iron catalyst during a preconditioning period at elevated temperatures and increased total pressure while maintaining a high hydrogen partial pressure and a relatively high mol ratio of H_2:CO until the catalyst is procured in a form resistant to fragmentation. The ratio of H_2:CO is then lowered to not more than 2:1 while maintaining said increased total pressure. High yields in hydrocarbons and oxygenated hydrocarbons are obtained.

U.S.P. 2,542,422. Synthesis of Organic Compounds. H. G. McGrath to The M. W. Kellogg Company.

In a Fischer-Tropsch hydrocarbon synthesis in the presence of a finely divided metallic iron catalyst, this catalyst is initially pretreated with a H_2/CO mixture at a temperature above 500° F. and a pressure of 15-90 psi. under conditions such that the catalyst is maintained in fluidized conditions. The pressure is then raised to above 100 psi. and the temperature to at least 600° F.

U.S.P. 2,542,454. Process for Manufacturing Hydrocarbons and Alcohols. G. B. Arnold and H. V. Hess to The Texas Company.

The reaction effluent of a Fischer-Tropsch synthesis operation is separated into a gas phase, a hydrocarbon phase and a water phase at a temperature of 175-350° F. and a pressure sufficient to maintain substantially liquid phase conditions. Oxygen-containing organic compounds are removed from the hydrocarbon phase. The water phase is countercurrently contacted with a portion of the thus refined hydrocarbon fraction under the same conditions of temperature and pressure. The hydrocarbon extract phase formed then contains nonacidic oxygenates and is combined with the hydrocarbon phase as originally separated. The aqueous raffinate of reduced nonacidic oxygenate content is discharged.

U.S.P. 2,542,464. Catalytic Conversion. J. F. Black and K. K. Kearby to Standard Oil Development Company.

A mixture of H_2 and CO containing these gases in the ratio of 0.8 to 1.1 is contacted under synthesis conditions at a temperature of 630-660° F., with a catalyst consisting of 99 percent reduced iron oxide and 1 percent KF.

U.S.P. 2,542,487. Production of Olefins from Oxides. J. A. Dinwiddie to Standard Oil Development Company.

Mono-olefin oxide, as obtained for example in a Fischer-Tropsch synthesis, is contacted with a metal or oxide of a group VIII metal catalyst and a promoter at a temperature of 400-1000° F. The corresponding mono-olefin is produced.

U.S.P. 2,542,488. Production of Olefins. J. A. Dinwiddie to Standard Oil Development Company.

The process of this patent is closely related to that of U.S.P. 2,542,487. An alkaline promoter, such as K_2CO_3, is here employed in an amount of 0.5-15 percent.

U.S.P. 2,542,517. Hydrocarbon Synthe-

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In every production race time is an exacting taskmaster. Equipment that clips minutes from previous job time helps win this race. And today the race is on in earnest. AIRETOOL refinery equipment, long recognized for dependability, is equally well-known for SPEED.
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Even an inexperienced operator can use this new AIRETOOL tube rolling control with uncanny accuracy and greatly increased speed. Jobs that used to take a full day are now finished in four hours or less. The control automatically shuts off the motor when the tube is properly expanded. No more over expansion. No more under expansion. Uniform rolling every time.
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Patents

sis. C. E. Hemminger to Standard Oil Development Company.

A CO/H_2 mixture obtained by treatment of a normally gaseous hydrocarbon with an oxygen-containing gas is contacted under synthesis conditions with a powdered suspended iron catalyst. The reaction effluent is cooled to form a hydrocarbon phase and an aqueous phase containing oxygenated hydrocarbons. At least a portion of the latter is recycled to the hot synthesis gas formed before whereby at least a portion of the oxygenated compounds is converted into hydrocarbons. Resulting mixture is cooled and separated from water before passing to the synthesis step.

U.S.P. 2,542,521. Process for Segregating Oxygenated Hydrocarbons. H. J. Hibshman and R. N. Dolph to Standard Oil Development Company.

A mixture of hydrocarbons and oxygenated hydrocarbons is introduced into a vertical tower at a point above its center. Silica gel in introduced at the top of the tower and removed from its bottom. A C_1-C_4 alcohol is introduced at the tower bottom. A side-stream product rich in oxygenated hydrocarbons other than acids is withdrawn from a point below the introduction of the feed mixture, while an overhead product rich in hydrocarbons is also withdrawn from the tower, and a bottom withdrawal rich in acids is obtained.

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U.S.P. 2,543,795. Production of Liquid and Gaseous Fuels by Synthesis from Coal. I. Mayer and H. J. Ogorzaly to Standard Oil Development Company.

Details are claimed of a continuous process for producing a fuel gas of high heating value from subdivided carbonaceous material, such as coal, and a subdivided catalytic material. The turbulent fluidized mixture of these materials is contacted with a CO/H_2 gas mixture at carbonization and methane synthesis conditions.

U.S.P. 2,543,974. Method for Synthesis of Organic Compounds. J. W. Jewell and W. B. Johnson to The M. W. Kellogg Company.

A CO/H_2 mixture is continuously passed through a plurality of alternate uncooled and cooled reaction zones. A finely divided hydrogenation catalyst is continuously introduced into the gaseous mixture. The reaction temperature is maintained at 300-750° F. under increased pressure. A linear velocity is maintained in the reaction zones such that the heaviest catalyst particles continuously move in the direction of the gas flow. A relatively short residence time of the catalyst in the reaction zones is thus insured.

U.S.P. 2,544,271. Production of Oxygenated Products from Petroleum. G. E. Liedholm and J. T. Harlan, Jr., to Shell Development Company.

In a two-step Oxo synthesis starting from olefins, CO, and H_2, a sulf-active hydrogenation catalyst is employed in the second synthesis step at a pressure materially lower than that employed in the first step. Special conditions are maintained.

U.S.P. 2,544,317. Treatment of Synthetic Naphtha. B. N. Hill and E. F. Wadley to Standard Oil Development Company.

Synthetic crude petroleum containing oxygenated organic compounds is distilled in the presence of a hydrocarbon fraction boiling in the lubricating oil range, an alkali metal sulfonate, and an alkali metal hydroxide. A distillate fraction boiling in the gasoline range and substantially free of oxygenated organic compounds is recovered.

DESULFURIZATION

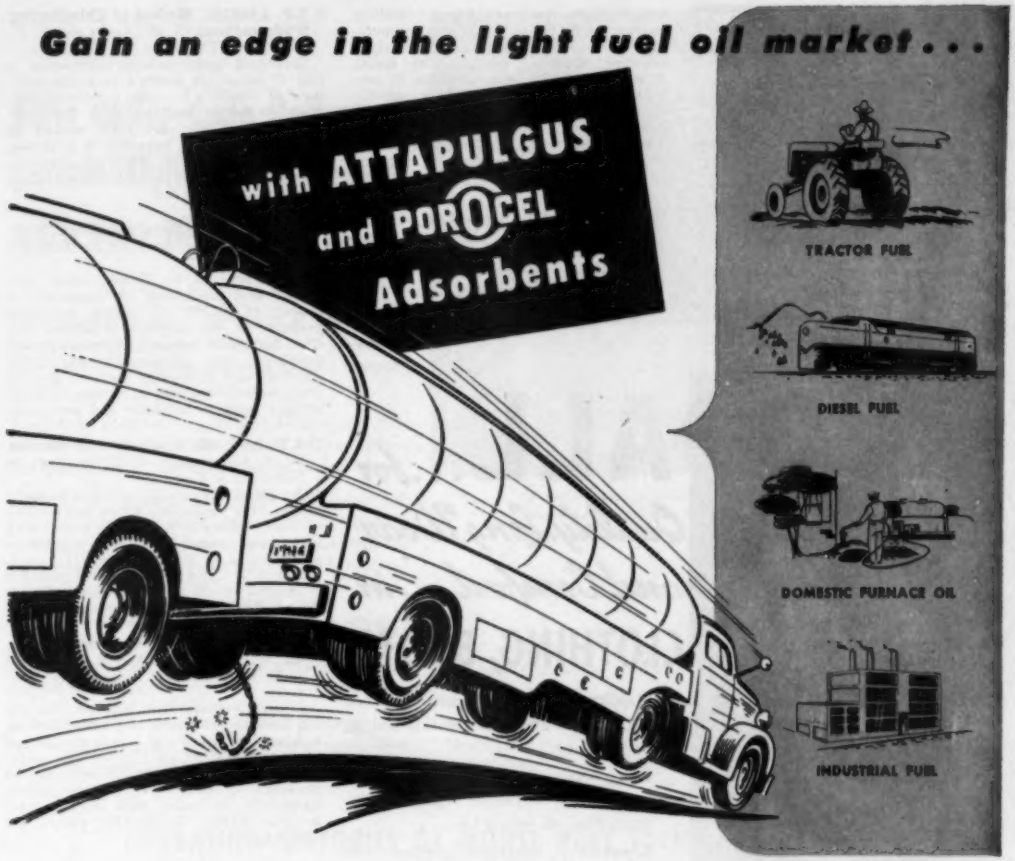
U.S.P. 2,542,147. Emulsion Breaking. W. A. Krewer and G. W. Ayers to The Pure Oil Company.

In sweetening sour hydrocarbons by treatment with an aqueous alkaline solution, a hydrocarbonaceous resinous material insoluble in the hydrocarbons and in the alkaline solution, e.g. a solid polyethylene or polystyrene resin, is maintained in the treating zone at the level of the interface, the hydrocarbons under treatment passing through the resin layer as they complete contact with the alkali solution. Emulsification is thereby substantially eliminated.

U.S.P. 2,543,953. Sweetening Hydrocarbon Mixtures. E. B. Backensto to Socony-Vacuum Oil Company, Inc.

A sour petroleum fraction is partially demercaptized, e.g. by means of an alkaline solutizer solution containing a tannin. The treated fraction containing not more than 0.005 percent by weight of mercaptan sulfur is mixed with a di-

Gain an edge in the light fuel oil market . . .



In a highly competitive market for distillate fuel oils—Diesel, domestic furnace, tractor, industrial—the refiner who places emphasis on high quality in his products has a decided edge. In fact, selling strategy often is based on points of superiority that assume smaller stature at other times. This applies to other products too—absorption, enrichment, smudge, and insecticide spray oils.

A final straining step using Attapulgus Fullers Earth or Porocel Activated Bauxite is an economically attractive form of light fuel oil quality insurance. These adsorbents are recognized standards for the selective "polishing" of light distillates at low cost. Oils in this range can be filtered to high yields for removal of moisture and sediment. Removal of residual amounts of treating chemicals is accomplished. Moisture haze is removed; color improved or stabilized.

Attapulgus and Porocel adsorbents couple low price with long service life—an unbeatable combination when finishing distillates whose market price generally dictates a minimum of refining expense. Process equipment required is relatively simple and inexpensive—often built from on-site components.

Let's explore the possibilities of improving your position—hence profits—in the light fuel oil market. Our staff is at your service to help select the right adsorbent and the right conditions.

ATTAPULGUS CLAY COMPANY *Fullers Earth* · **POROCEL** CORPORATION *Activated Bauxites*

Dept. W, 210 West Washington Square, Philadelphia 5, Pa.

secondary butyl catechol in the presence of alkali metal hydroxide. The petroleum fraction is sweetened.

PETROCHEMICALS

U.S.P. 2,541,408. Catalytic Chloromethylation of Aromatic Compounds. F. O. Cockerille to Ciba Pharmaceutical Products, Inc.

Aromatic compounds, such as naphthalene, are monochloromethylated with gaseous HCl and paraformaldehyde in stoichiometric proportions in an aqueous medium containing a catalytic amount of As_2O_3 or $AsCl_3$ at a temperature below 100° C. The reaction mass is maintained out of contact with metal. A volume of the aqueous phase is provided such that the medium steadily remains sufficiently fluid to permit efficient stirring of the reaction mixture. The formation of diarylmethane derivatives and resinous by-products is essentially avoided.

U.S.P. 2,541,673. Weak-Acid Isopropanol Process. B. I. Smith to Standard Oil Development Company.

Details are claimed of a process for the production of isopropyl alcohol from propylene-rich hydrocarbon material and H_2SO_4 of about 70 percent concn.

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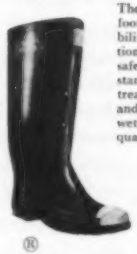

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U.S.P. 2,542,107. Method of Chlorinating Hydrocarbons. G. W. Ayers and E. E. Harton to The Pure Oil Company.

Saturated hydrocarbons containing a tert. C atom are reacted at a temperature of 70-150° F. with a chlorinating agent in the presence of PCl_5, $ZnCl_2$ or a chloride of the rare earth metals as catalyst and in the presence of a drying agent. The mol ratio of hydrocarbons to chlorinating agent is maintained at a ratio greater than 8:1.

U.S.P. 2,542,747. Olefin Reactions. P. L. Barrick to E. I. du Pont de Nemours & Company.

A mixture of an olefin, cobalt carbonyl, and hydrogen or ammonia is heated at 25-250° C. under increased pressure in the absence of added free CO. Saturated organic compounds are produced, e.g. propionaldehyde from ethylene and hydrogen, isoamyl alcohol from isobutylene and hydrogen, isoamyl amines from isobutylene and ammonia.

U.S.P. 2,542,766. Production of Amides. W. F. Gresham to E. I. du Pont de Nemours & Company.

An olefin CO, and ammonia a primary amine, or a secondary amine are heated, in the presence of a catalyst comprising an organic cobalt compound soluble in at least one of the reactants, at a temperature of 150-350° C. under a pressure in excess of 50 atm. Amides are produced. The catalyst is recycled.

U.S.P. 2,542,767. Organic Ester Synthesis. W. F. Gresham and R. E. Brooks to E. I. du Pont de Nemours & Company.

A non-aromatic hydrocarbon containing olefinic unsaturation, e.g. ethylene, is heated with CO and a primary alcohol at a temperature of 150-500° C. under a pressure of at least 50 atm. in the presence of metallic cobalt, its oxides, carbonyls, or salts with organic carboxylic acids. Carboxylic esters are formed.

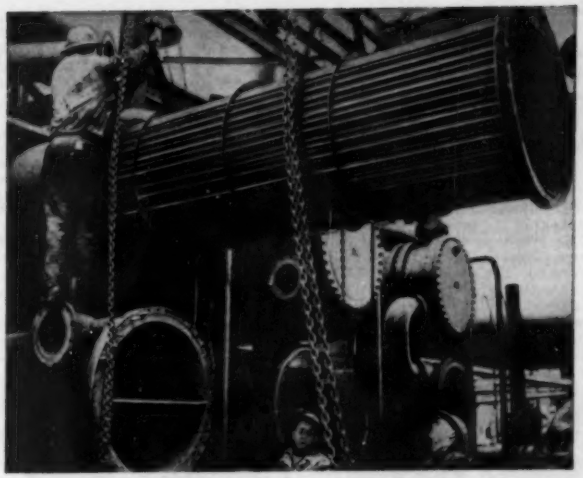
U.S.P. 2,542,985. Preparation of Acetophenone from Alpha-Methyl Styrene. G. R. Bond, Jr., to Houdry Process Corporation.

A hydrocarbon fraction rich in alpha-methyl styrene is reacted with N_2O_4 at a temperature not in excess of 100° F. until completion of the reaction. Unreacted hydrocarbons are separated from the resulting nitrosate by steam distillation. The distillation residue containing the nitrosate is treated with twice its volume of 10 percent NaOH solution. The alkaline reaction mass is steam distilled to obtain an acetophenone distillate.

U.S.P. 2,543,820. Alcohol Process. F. M. Archibald and H. O. Mottern to Standard Oil Development Company.

A secondary aliphatic alcohol is produced by treating an aliphatic hydrocarbon mixture comprising normal mono-olefins, tert. mono-olefins, and polyolefins (e.g. butenes, isobutylene, and butadiene) with a weak mineral acid (e.g. 62-70 percent H_2SO_4). The bulk of the tert. mono-olefins and polyolefins is polymerized and separated. The remaining hydrocarbon mixture is contacted with a polymerization catalyst to polymerize the rest of the tert. mono-olefins and polyolefins still present. The remaining normal mono-olefins are contacted with a strong mineral acid (e.g.

New Boiler Code Rulings permit Higher Temperatures with INCO Nickel Alloys



A cleaned exchanger tube bundle being replaced in its shell. "Spring-cleaning" like this prevents failures in service and insures efficient heat exchange. *Photo courtesy The M. W. Kellogg Co., New York, N. Y.*

New interpretations of the A.S.M.E. Boiler Code have raised temperature limits on INCO Nickel Alloys used in the construction of unfired pressure vessels.

Also, in addition to annealed Monel, it is now permissible to use stress-relieved Monel, which has substantially higher mechanical properties.

These two modifications of the code mean that it is now possible to build stronger and lighter heat exchangers for higher temperature service, *that are insurable because they are built to code requirements.*

But this modified code applies only to physical properties. To overcome corrosion troubles, users must assume the responsibility for choosing the correct materials.

A glance at the table will show how some users have been able to get greatly increased equipment life by the proper choice of heat exchanger metals...

To see if INCO's Corrosion Engineering Service can help you, write, outlining your problem.

And at the same time, ask for a free copy of the new "Boiler Code Interpretations Involving Nickel, Monel, Inconel." It lists the new stress and temperature limits for the INCO Nickel Alloys.

OPERATING HISTORIES OF MONEL HEAT EXCHANGER TUBING

Case No.	Products Handled		Highest Temperature	Service Life		
	Inside tubes	Outside tubes		Previous Material	Monel tubes	Condition of Monel at last inspection
1	Steam	Caustic	350	2-8 weeks	17 months	Good—still in service
2	Foul Caustic	Steam	300	5 months	25 months	No evidence of corrosion
3	Heavy recycle	Straight run gasoline distillate	550	6665 hours	38,535 hours	Renewed 24 tubes after 22,000 hours—3 tubes plugged at 38,535 hours. Remainder OK.
4	Caustic soda and sodium chloride	Steam	240	10 months	80 months	Good—15 tubes replaced—weld failures
5	Crude oil	Gasoline vapor	300	6-8 months	48-60 months	No inspection

Service information on heat exchangers closely similar to yours is probably not in this table. However, help is available from INCO's Corrosion Engineering Service. From their thousands of data sheets showing corrosion rates in a wide variety of media, it is likely that an answer to your specific problem can be found.

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Inconel® • Inconel "X"®

Patents

83-92 percent H_2SO_4). The resulting acid extract is hydrolyzed to obtain sec. aliphatic alcohol.

U.S.P. 2,543,842. Polysulfone Resin Process and Composition. F. E. Frey to Phillips Petroleum Company.

A straight-chain olefin with at least 4 C atoms is reacted with SO_2 in molar excess in the presence of a suitable catalyst, such as $LiNO_3$, until a resinous mass plastic at room temperature is formed. The uncombined SO_2 works as a plasticizer in this mass. A monomeric alkenyl sulfone is then admixed to react with the uncombined SO_2, whereupon the mass is molded.

U.S.P. 2,543,885. Water-Soluble Petroleum Sulfonates. C. E. Wilson to Union Oil Company of California.

A hydrocarbon fraction boiling between 500-800° F. is reacted with a strong sulfonating agent at elevated temperature. The resulting crude sulfonation product is extracted with certain aromatic or chlorinated aromatic hydrocarbons, or polychlorinated aliphatic hydrocarbons. The extract obtained is further treated to obtain water-soluble hydrocarbon sulfonates.

U.S.P. 2,544,164. 2-Bromothiophene. C. E. Johnson and G. M. Wagner to Michigan Chemical Company.

Preheated and then vaporized bromine is introduced into thiophene. 30-70 percent of the bromine theoretically required to convert the thiophene to 2-bromothiophene are employed at a reaction temperature above 20° C. 2-bromothiophene is produced.

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HEAVY OILS AND WAXES

U.S.P. 2,541,590. Lubricating Compositions. R. G. Larsen and K. E. Marple to Shell Development Company.

A mineral lubricating oil contains a minor amount of a copolymer of 2-25 percent of a diester of phthalic acid with an unsaturated aliphatic alcohol having 2-3 C atoms and 97-75 percent of an ester of an allyl alcohol containing 3-18 C atoms with a saturated monocarboxylic acid of 8-13 C atoms. The copolymer shall have a polymerization degree of 4.3-12.1 and is obtained by heating the said mixture at 50-300° C., in the presence of an organic peroxide or a metallic salt catalyst. The viscosity index of the lubricant is appreciably increased by the additive.

U.S.P. 2,541,686-7. Lubricating Oil. J. M. Butler to Monsanto Chemical Company.

A paraffin wax containing hydrocarbon lubricating oil with a pour point of 30-65° F. contains a dispersion of 0.05-2 percent by weight of polyallyl myristate to effect depression of the pour point. According to U.S.P. 2,541,687 the pour point of 40-70° F. of a hydrocarbon oil is depressed by a similar percentage of polyallyl palmitate.

U.S.P. 2,541,789. Mineral Oil Lubricant Containing Sulfurized and Phosphorized Propylene and Butylene Glycol Esters of Oleic Acid. J. B. Stucker to The Pure Oil Company.

A midcontinent solvent refined petroleum lubricating oil contains as an additive a sulfurzide and phosporized ester of propylene or butylene glycol dioleate with a sulfur content of 1-10 percent and a phosphorous content of 0.2-0.6 percent. The additive is soluble in the oil and improves its load carrying characteristics.

U.S.P. 2,542,159. Continuous Grease Manufacture. L. B. Stevens to The Pure Oil Company.

A slurry of sodium soap in mineral oil is heated to a temperature of 220-290° F. at which the soap is above its plasticity point but below its true m.p The slurry is homogenized at this temperature to grease structure.

U.S.P. 2,542,161. Mineral Lubricant Containing Phosphorized and Sulfurized Glycerol Trioleate. J. B. Stucker to The Pure Oil Company.

A mineral lubricating oil contains as extreme pressure additive 0.5-20 percent by weight of a reaction product of phosphorous sesquisulfide and sulfurized glyceryl oleate, mainly the trioleate thereof.

U.S.P. 2,542,286. Lubricating Oil Containing Chlorinated Cyclic Polymer. R. C. Morris, J. L. Van Winkle, and A. V. Snider to Shell Development Company.

A mineral lubricating oil contains 0.1-20 percent by weight of a chlorinated cyclic polyer prepared in a special manner from a methyl 1,3-pentadiene, SO_2, Cl_2.

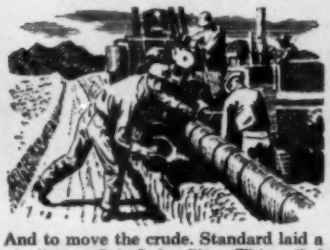
"Why should you be in all parts of the oil business?"

Mrs. Henry Lincoln, housewife in Boise, Idaho, asks: *"Do you have to be in all parts of the oil business? Why don't you just produce or refine, and give other companies a chance to do the transporting, selling, etc.?"* Mrs. Henry Lincoln

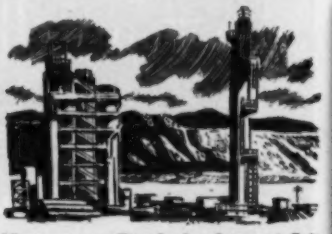
Why *all* parts? Take the example of how Standard serves Idaho and eastern Oregon. Time was when severe winter weather often delayed deliveries. Costs seemed high. Here was a *need*, a *demand*.

Some 600 miles away in Colorado was a possible source of additional fuel—the old Rangely oil field, long undeveloped. Standard studied the *demand* and the *supply*, decided to bring them together.

That called for a complete, *integrated* operation—getting the crude out of the ground, refining it, delivering it to users—all carefully planned ahead. So new wells were drilled at Rangely.



And to move the crude. Standard laid a pipeline to Salt Lake City. This called for an especially big investment because the 182 mile long line is the world's highest: crosses the Uinta Mts. at 9560 feet.



Next—a new Standard refinery at Salt Lake City. It cost over $15 million. But to keep costs down, it must operate continuously—have constant supply of crude, constant movement of product.

Another long pipeline was then built on up to the Northwest. Gasoline and fuel oil made from Rangely crude now go where they're needed—lower in cost, plentiful no matter how tough the winter.

If Standard had not been prepared—in *size*, in *integrated skills*, in *investment capital*—to tackle this job as it did, it could not have done this job at all. As it is, we are able to serve a large area *well*.

I'd Like to Know . . .

You may have heard that a suit has been filed by the Antitrust Division in Washington, D. C. to break up Standard of California as well as six other West Coast oil companies. Many people have written us protesting this action, have asked pertinent questions. We believe these questions should be answered for everyone. We take this way of doing so. If you have a question, write:

"I'd Like to Know"
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STANDARD OIL COMPANY OF CALIFORNIA

• plans ahead to serve you better

Patents

U.S.P. 2,542,542. Lubricating Oil Additives. S. B. Lippincott and L. A. Mikeska to Standard Oil Development Company.

An oil base stock contains 0.01-10 percent by weight of a copolymer of maleic anhydride and octadecene prepared in a specified manner. The additive has high pour depressant potency.

U.S.P. 2,542,553. Mineral Oil Composition. L. A. Mikeska and P. V. Smith, Jr., to Standard Oil Development Company.

A mineral oil base stock contains 1-20 percent by weight of a compound of the formula

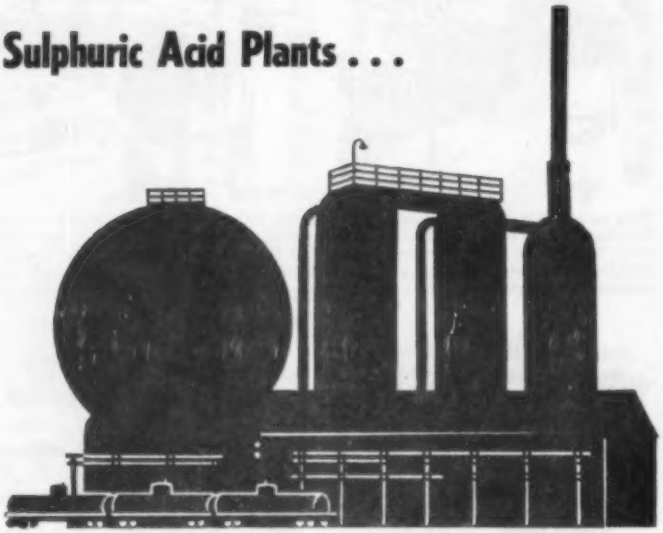
$$Cl_3C\text{-}CH(SR)\text{-}Y\text{-}H$$

wherein R is an alkyl group with 2-20 C atoms and Y is O or S. The additive imparts extreme pressure properties to the lubricant.

U.S.P. 2,542,604. Extreme Pressure Lubricant and Extreme Pressure Agents Therefor. C. A. Weisel and E. B. Cyphers to Standard Oil Development Company.

A mineral base lubricating oil contains 0.1-20 percent by weight of a material of the formula $(RO)_2P(=O)A$ where R is an alkyl group of 6-20 C atoms and A is a pentachlorphenol radical. The additive imparts extreme pressure properties to the lubricant.

Sulphuric Acid Plants . . .



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and Recovery Plants

Nicolay Titlestad Corp. offers a specialized engineering service for those seeking experience, initiative, and engineering in building, or modernizing acid plants and concentrators of all types and sizes.

Inquiries invited. No obligation.

NICOLAY TITLESTAD
CORPORATION

11 West 42nd Street **New York 18, N. Y.**

U.S.P. 2,542,831. Mineral Oil Composition and Improving Agent Therefor. E. A. Oberright to Socony-Vacuum Oil Company, Inc.

A viscous mineral oil fraction contains an admixture, e.g. 0.01-5 percent of a compound of the formula $R_a\text{-}A\text{-}Y_b(OM)$ wherein A is a carbocyclic aromatic nucleus, M is hydrogen or a metal, R is a saturated aliphatic hydrocarbon group, a is an integer of at least one, Y is an alkenyl radical the olefinic bond of which has been satisfied by the addition of a sulfur atom and b is an integer of at least one. The additive stabilizes the oil.

U.S.P. 2,542,981. Unsaturated Tertiary Amine-P_2S_5 Reaction Products and Lubricating Oils Containing Same. J. D. Bartleson and E. C. Hughes to The Standard Oil Company (Ohio).

A mineral lubricating oil contains 0.01-10 percent by weight of a reaction product of P_2S_5 and an unsaturated tert. amine containing a straight chain hydrocarbon radical of 10-18 C atoms and one olefinic double bond obtained at a temperature of 250-600° F. The additive inhibits deterioration of the oil while in use.

U.S.P. 2,542,982. Unsaturated Amine-Sulfur Reaction products as Lubricant Additives and Lubricating Oils Containing Same. J. D. Bartleson and E. C. Hughes to The Standard Oil Company (Ohio).

The object of this patent is closely related to that of U.S.P. 2,542,981. An oil dispersible reaction product of an unsaturated amine of the type named in this patent and 0.1-1 atom of sulfur per olefinic double bond of the amine is here employed as the additive.

U.S.P. 2,543,074. Stabilized Oxidizable Hydrocarbon Oil. W. T. Stewart and J. O. Clayton to California Research Corporation.

An oxidizable hydrocarbon oil contains a small amount of a compound of the formula R-X-H wherein X is Se or Te and R is an aliphatic group of 5-30 C atoms. The additive inhibits oxidation of the oil.

U.S.P. 2,543,325. Anticorrosive Lubricating Oil Composition. R. W. Mattson to Union Oil Company of California.

A mineral lubricating oil contains 0.1-3 percent by weight of a mercaptal, a mercaptol, or a trithio ortho ester. This compound shall contain at least one substituent —OR group where R is hydrogen or a hydrocarbon radical. The additive imparts anticorrosion properties to the oil.

U.S.P. 2,543,542. Mineral Oil Composition. D. E. Badertscher and C. F. Feasley to Socony-Vacuum Oil Company, Inc.

A viscous mineral oil fraction contains a small amount of an oil-soluble reaction product of one mol of a terpene and 2 mols of mercaptan obtained by a special process. The additive stabilizes the oil against oxidation.

U.S.P. 2,543,734. Mineral Lubricating Oil Containing a Combination of Metal Salts. W. T. Stewart and J. O. Clay-

Horton* structure helps recover coke fines

*By Horton structure, we mean the bottom and shell rings of the Dorr thickener unit shown at the right and below.

This unit is located at the East St. Louis refinery of the Socony-Vacuum Oil Company. It separates coke fines from water in a hydraulic decoking process.

Thickener unit at East St. Louis, Ill.

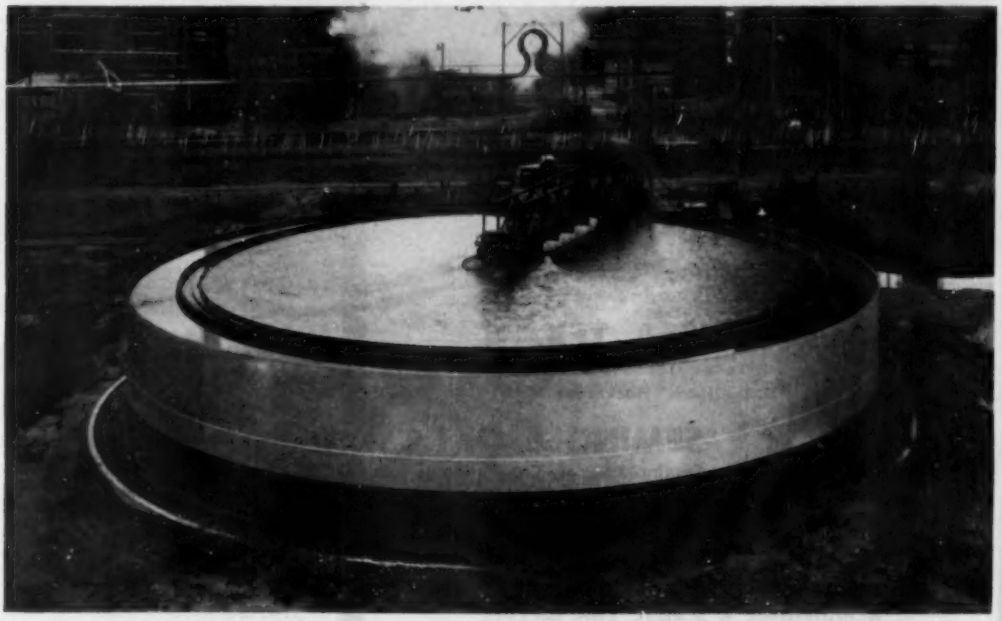
In a hydraulic decoking process, streams of high-velocity water are used to remove the coke from the drum. Most of the coke is cut into large lumps that fall from the drum directly into a railroad car. An appreciable quantity, however, is in the form of small particles—coke fines—that remain in suspension in the water.

The thickener concentrates these fines so they can be recovered. The unit also clarifies the water so it can be re-used.

The coke water slurry is first pumped through a screened basin at the center of the unit. It then passes into the settling basin (inner tank). Coke particles gradually settle on the bottom and are moved gently to a discharge outlet by slowly moving plow blades.

The clarified water overflows from the settling basin into the outer, or surge, tank. The surge tank acts as a reservoir of clarified water that can be used again for cooling and cutting out more coke from the coking drums.

This steel plate installation is an example of the special structures we can build. We also fabricate and erect such standard structures as oil storage tanks, water storage tanks and processing towers and columns. Write our nearest office for information or quotations.



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Birmingham 1 ..... 1548 North Fiftieth Street
Boston 10 ..... 1030—201 Devonshire Street
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Cleveland 15 ..... 2234 Guildhall Building
Detroit 26 ..... 1520 Lafayette Building
Houston 2 ..... 2126 National Standard Building
Los Angeles 17 ..... 1534 General Petroleum Building
New York 6 ..... 3302—165 Broadway Building
Philadelphia 3 ..... 1608—1700 Walnut Street Building
Salt Lake City 4 ..... 331 West 17th South Street
San Francisco 4 ..... 1551—200 Bush Street
Seattle 1 ..... 1331 Henry Building
Tulsa 3 ..... 1626 Hunt Building
Washington 6, D. C. ..... 1128 Cafritz Building

REPRESENTATIVES AND LICENSEES

Ateliers et Chantiers de la Seine Maritime, Paris, France
Compagnia Tecnia Industrie Petroli, Roma, Italy
Constructions Metalliques de Provence, Arles-sur-Rhone, France
Chicago Bridge & Iron Company, Ltd., Apartado 1348, Caracas, Venezuela
Horton Steel Works, Limited, Fort Erie, Ontario, Canada
Motherwell Bridge & Engineering Company, Limited, Motherwell, Scotland
Whessoe, Limited, Darlington, England
Comprimo N. V., Amsterdam—O, Netherlands
Sociedade Chibridge de Construcoes Ltda., Rio de Janeiro, Brazil

ton to California Research Corporation.

A mineral lubricating oil contains 0.1-2 percent by weight of an oil-soluble polyvalent metal salt of a phenate or an aromatic sulfonate and 0.1-5 percent of a polyvalent metal salt of an alkyl selenomercaptan with 5-30 C atoms. The additive stabilizes the oil against oxidation and reduces corrosiveness.

U.S.P. 2,543,964. Mineral Oil Compositions Containing Copolymers of Olefins and Esters of Alpha, Beta-Unsaturated Polybasic Acids. J. J. Giammaria to Socony-Vacuum Oil Company, Inc.

A lubricating oil contains a copolymer obtained by a special process from an aliphatic mono-olefin having a double bond in the alpha position and up to 30 C atoms and a certain type of an alkyl diester of an alpha, beta-unsaturated dicarboxylic acid. The additive lowers the pour point of the oil.

U.S.P. 2,544,307. Method for Removing Oil from Filter Cakes. F. L. Fourrier and J. Opryshek, Jr., to Standard Oil Development Company.

A wax containing lubricating oil is diluted with a normally gaseous hydrocarbon, e.g. liquefied propane, chilled, and dewaxed to form a filter cake. The dewaxed solution is contacted with H_2SO_4, and the normally gaseous hydrocarbon is removed. Further details are claimed.

U.S.P. 2,544,375. Lubricating Oil Containing a Polymer of Tetradecyl Vinyl Ether. J. M. Butler to Monsanto Chemical Company.

A wax containing mineral lubricating oil contains 0.05-2 percent by weight of a dissolved polymer of tetradecyl vinyl ether for depressing its pour point to an A.S.T.M. of 15-50° F.

U.S.P. 2,544,376. Lubricating Oil Containing a Polymer of Oleyl Methylacrylate. J. M. Butler to Monsanto Chemical Company.

The patent is closely related to U.S.P. 2,544,375. A polymer of oleyl methacrylate is here employed as the additive to depress the ASTM pour point to −10° to +5° F.

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Fieldner and McCabe Made Chiefs of Mines Department

Bureau of Mines officials announced the appointments of Drs. Arno C. Fieldner to chief fuels technologist on the staff of Director James Boyd, and Louis C. McCabe to chief of the Fuels and Explosives division in Washington. Dr. Fieldner has been associated with the Bureau for 40 years while Dr. McCabe joined the organization in 1946.

In 1942 Dr. Fieldner was awarded the Melchett Medal by the Institute of Fuels in England for his outstanding achievement in scientific preparation or use of fuel. He guided the research and experimentation in the production of synthetic liquid fuels at the initial Pittsburgh laboratory in the 1930's and helped provide a base for the Bureau's national synthetic liquid fuels research and demonstration program authorized in 1944.

Dr. McCabe, a native of Arkansas, holds a Ph.D. in geology-mining from the University of Illinois. In 1946 he became chief of the coal division in the fuels and explosives service and in 1947 he became director of the Los Angeles Air Pollution Control District but returned to the Bureau of Mines in 1949 to head a new air and stream prevention research.

Ethanolamine May Bolster Sulfur Supply

Increased output of ethanolamine has been authorized at The Dow Chemical Company and may be an important factor in bolstering the nation's dwindling natural sulfur reserves according to C. B. Branch, manager of Dow's technical service and development.

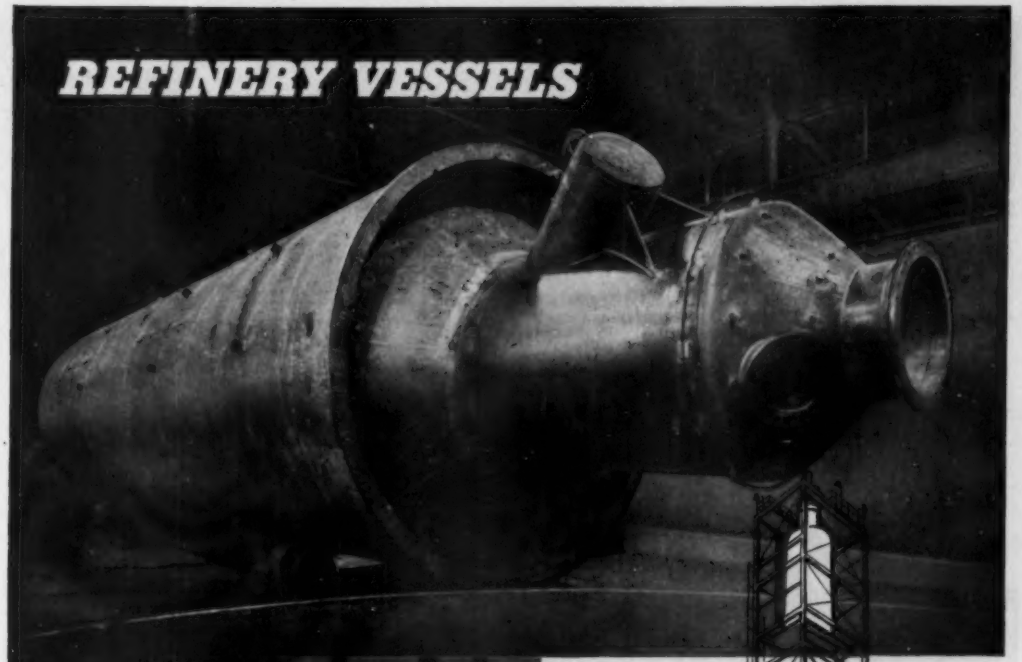
Ethanolamine, Branch explained, is being currently used by several Dow customers to remove sulfur in the form of hydrogen sulfide from natural gas, and in some instances this sulfur is being converted to sulfuric acid.

Hydrogen sulfide is removed by washing the gas with an ethanolamine solution. The hydrogen sulfide is then removed by heating the solution which can be reused for gas purification. Elemental sulfur is obtained by burning the recovered hydrogen sulfide.

Instrument Conference

The sixth national Instrument Conference and Exhibit will be held in Sam Houston Coliseum, Houston, from September 10-14. This is the first time the Exhibit has been held in Houston and it is reported that attendance will also

REFINERY VESSELS



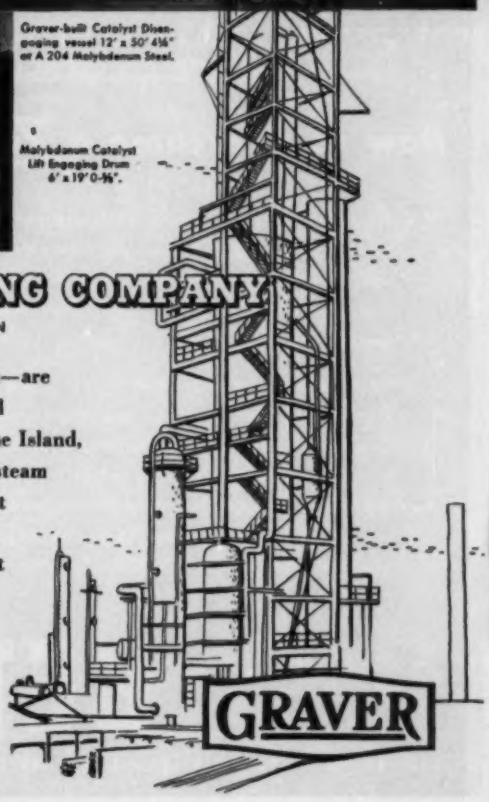
Graver-built Catalyst Disengaging vessel 12' x 50' 4½" of A 204 Molybdenum Steel.

Molybdenum Catalyst Lift Engaging Drum 6' x 19' 0-½".

for GREAT LAKES REFINING COMPANY

DIVISION OF PETCO CORPORATION

Fabricated by Graver—among other tanks and vessels—are two refinery vessels of ASTM A 204 molybdenum steel for Great Lakes' new 6,000 b/d Houdriflow unit at Blue Island, Illinois. Since Graver's vessels function as part of the steam catalyst lift, the special steel provides great strength at the high temperatures required by the process. These fabrications are typical of the unusual skills that Graver possesses in stainless, alloys and clads, both in its shop work and in field erections.



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HOUSTON • SAND SPRINGS, OKLA.

set a "first" as a sizeable portion of the science and industry instrument manufacture lies in the near vicinity. Of 213 booths laid out, virtually all have been reserved by exhibitors.

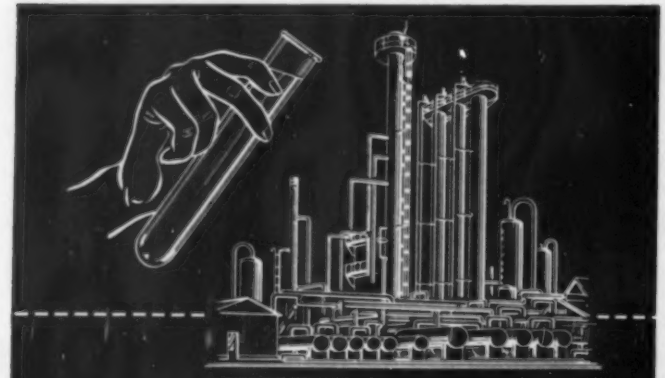
A Mechanics Maintenance Clinic will be held just prior to the main conference and exhibit at Houston.

Ohio Sportsmen Honor Sohio for Anti-Pollution

The Ohio Conservation Congress last month presented a special "citation of merit" to The Standard Oil Company (Ohio) for outstanding anti-pollution work during 1950 at its refineries in Cleveland, Toledo and Lima.

Pat Patterson, Cleveland, president of the Congress said: The interests of sportsmen and of basic industry meet along our streams. Industry requires unbelievable quantities of water; for example, the Cleveland refinery alone uses more water each day than the entire city of Columbus.

While water used by the three Standard refineries in Ohio is in part used over and over again, some of it is discharged back into the stream, but only after it has been chemically treated, cooled, aerated and the oil removed. This adherence to anti-pollution measures, as well as the oil and water-separation systems at Cleveland and Lima, and the action of Lima refinery employes who raised 10,000 bluegills in the operating condenser tanks and stocked a big water reservoir, prompted the citation.



How to overcome a *Liability*

Any plant becomes a liability when improper water conditioning eats up profits by causing excessive corrosion, scale or biological fouling. But this liability can be eliminated *provided* a proper program of chemical treatment and control is followed.

For the solution of even the most unusual cooling water problem BETZ offers a complete consulting engineering service. Over two decades of experience have made BETZ water conditioning service scientifically correct, complete . . . economical. Let our nationwide staff of engineers show how you can cut costs. Write today! There's no obligation, of course. W. H. & L. D. BETZ, Gillingham and Worth Streets, Philadelphia 24, Pa.

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Socony-Vacuum Sweeps Safety Award Field

Of 298 oil companies participating in the National Safety Council's annual safety contest, Socony-Vacuum Oil Company, Inc., and two of its affiliates, General Petroleum Corporation and Magnolia Petroleum Company, held leading positions in the various groups to which awards are made.

Socony-Vacuum's refinery at Paulsboro, N. J., was judged the safest among larger individual refineries in the world. This is the second successive year that Paulsboro refinery has been in first place. The company's Augusta, Kan., refinery held third among the smaller refineries.

Safety figures show that a Socony-Vacuum employe is more than twice as safe on the job as is the average industrial or oil industry worker.

George Merrick Named Industrial Relations Chief

George C. Merrick has been named industrial relations supervisor for Stanolind Oil and Gas Company's Texas-Louisiana Gulf Coast Division. Merrick comes to Houston from Brownsville, Texas, where he was industrial relations supervisor for Stanolind's new chemical plant.

A native of Illinois, Merrick joined Stanolind in 1940 after graduating from Yale University. After military service he returned to Stanolind in the industrial relations department, Tulsa. He has been at the Brownsville Chemical Plant since December, 1949.

George Vanderbilt Is Sohio General Auditor

The Standard Oil Company (Ohio) has appointed George T. Vanderbilt as general auditor of the company and its subsidiaries. He will succeed W. G. Daniels who will retire this year after eighteen years service with the company. Vanderbilt joined the company in 1917 as a stenographer-clerk in the Cincinnati office.

L. A. Boyd Joins Born

L. A. Boyd has been appointed chief engineer for the Born Engineering Company, Tulsa, according to Dr. Sidney Born, president.

Boyd, formerly chief engineer of Texas Natural Gasoline Corporation, and a member of the Oklahoma and National Society of Professional Engineers, has an extensive background in processing, research, design and development. He is known as instrumental in the development of gas stripping of natural gasoline plants and also was one of the pioneers in the use of extensive air cooling in natural gasoline plants.

New Sunray Officers

Sunray Oil Company has promoted three men who joined the organization in 1950 at the time of the merger with Barnsdall, to vice presidencies. The men are M. Darwin Kirk, vice president and general attorney; Harold W. Manley, vice president and gas-gasoline manufacturing department, and R. E. Foss, vice president and general superintendent for Sunray's California production division.

Zallea Expansion Joint News

PUBLISHED BY ZALLEA BROTHERS—WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

Expansion Joint of the Month

WORLD'S 8 LARGEST JOINTS!

LOW PRESSURE TYPE

The Figure No. 8 Zallea Low Pressure Corrugated Expansion Joint is used to absorb vibration and protect machinery. Made of stainless steel, this joint is of the non-equalizing type and is limited in service to ½" maximum axial movement and 50 lbs. maximum pressure. Furnished with multiple corrugations, it is primarily used on condensers, turbines, stage bleeders, pumps, and between connected equipment where slight movement and

Figure No. 8 Type

vibration occur. Variations of the Figure No. 8 design are available in diameters up to 30 feet in diameter for low and medium pressure service. Where transportation limitations prevent shipment in one piece, arrangements can be made for on site manufacture. These units, like all Zallea Expansion Joints, are produced without circumferential welds in the corrugated element.

. . . a brand new 4-page folder on *all* Zallea Expansion Joints. Send for your copy of Bulletin 351 today!

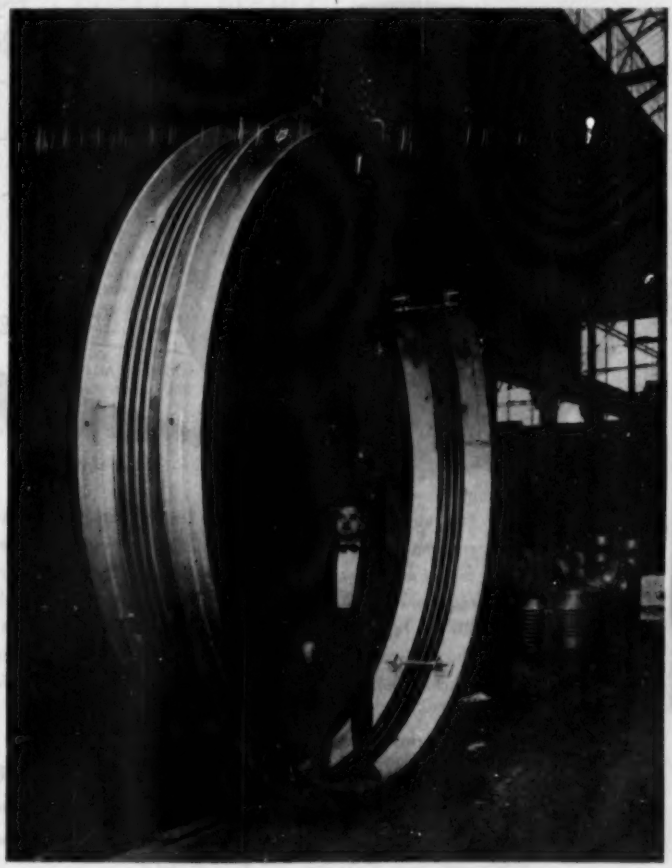
ZALLEA BROTHERS, 890 Locust Street, Wilmington 99, Delaware.

Keeping pace with expanding industrial needs, Zallea Brothers has just completed construction and delivery of the largest expansion joints ever built.

Thirteen feet in diameter, these Zallea Figure No. 8 Stainless Steel Expansion Joints, totaling 8 in number, are installed in a wind tunnel project at Lewis Flight Propulsion Laboratory, NACA, Cleveland, Ohio.

These huge joints are installed in the header between the primary and secondary coolers in the altitude exhaust ducts which convey exhaust gases from full scale thermal jet engines, aircraft engines, turbines, burners and other equipment undergoing tests in simulated altitude conditions.

These Zallea Stainless Steel Expansion Joints are used in air service with a working pressure from vacuum to 60 pounds at a temperature between minus 50 to plus 65 degrees F.



Top results are insured through the uniform quality of Davison synthetic fluid-type cracking catalysts. Years of experience and research make it possible for Davison to better control physical characteristics and maintain chemical purity of their catalysts. Your requirements can now be supplied in either microspheroidal (M-S*) or ground (DA-1*) form . . . both available in various average particle sizes.

The Davison "D" also stands for dependability. Likewise, you can depend on Davison facilities for the development and production of catalysts for your specific processes.

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NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information about products described on these pages use the coupon below, circling the number shown for each item desired. Or write the manufacturer direct to address as shown.

Mercury Cleaner

1 Bethlehem Apparatus Company, Front and Depot Streets, Hellertown, Pa., has developed a large-size mercury oxifier and filter to clean mercury. With a capacity of 150 pounds it can clean mercury of dissolved base metals up to 600 pounds a day in 150 pound batches. When used in combination with the Type H filter it also eliminates floating impurities. An electric motor powers a set of paddles which beat the mercury and whip it into a thick spray for several hours. As base metal contaminants come in contact with air, they oxidize and form a powder which precipitates as a dry, non-cohesive dust. H filter, based on the gold adhesion principle, removes everything but suspended iron and dissolved metals. Its capacity is 250 pounds in ten minutes. The oxifier is cleaned electrically by manual switch. Unit is welded construction, the mercury holding cylinder is lined with acid and wear-resistant Lastiglas. Stands 21 inches high, requires floor space 21 by 36 inches, weighs 250 pounds.

Table on Tolerances

2 The Babcock & Wilcox Tube Company, Beaver Falls, Pa., has announced the latest edition of a table on tolerances for round seamless carbon and alloy steel mechanical tubing, giving permissible variation in diameter and wall thickness. Designated data card, 1150, it refers to cold-drawn-unannealed and finished-annealed tubing in sizes 8⅞ inches outside diameter, and to hot-finished tubing in sizes 9¾ inches outside diameter.

Temperature Control Book

3 Catalog Number 18 provides a useful aid in precise and reliable temperature control and regulation according to H-B Instrument Company, 2633 Trenton Avenue, Philadelphia 25. H-B Thermo-Regulators and Thermostats may be selected from plus or minus 0.0005° F. to plus or minus 0.10° F. The equipment described includes advanced design Quick-Set and Red-Top Thermo-Regulators, and the H-B Multi-Contact Thermo-Regulators, and H-B Multi-Contact Thermo-Regulators with three to 14 operating contacts as well as more simple types. Range extremities are minus 35° F. to 350° F.

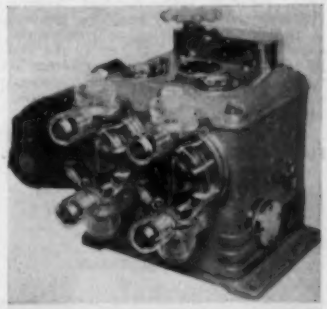
Detergents in Industry

4 How solvent detergents provide benefits in industrial cleaning applications is discussed in a booklet printed by Oakite Products, 150B Thames Street, New York 6. The booklet reports upon the classifications of cleaning in which solvent detergents are being successfully used: removing oily films, smuts, cutting, drawing and stamping compounds from steel in metal fabrication process, and also gives specific applications.

Needle Valves

5 Kerotest Manufacturing Company, 2525 Liberty Avenue, Pittsburgh 22, has published a folder describing its line of forged steel, union bonnet Needle Valves for high-pressures and corrosive services. Described valves are available in ⅛, ¼, ⅜, ½ and ¾-inch sizes, for working pressures up to 4000 pounds at 150° F., and are available in carbon steel, stainless steel 12-14 chrome and in 18-8 mo. stainless steel throughout.

Chemical Feeder



6 %Proportioneers, Inc.%, Harris Avenue, Providence, R. I., announced a new Model 2-47CF Constaflo Chemical Feeder which they claim provides positive displacement; is equipped with a duplex diaphragm pump with two "See-Thru" plastic reagent heads, and is driven by a ¼-hp. motor. Recommended delivery range is from 1.0 to 15 gallons per hour. Constaflo will draw solutions or slurries from a container and force them into a line or vessel under pressures up to and includ-

FOR ADDITIONAL INFORMATION on products and literature mentioned in this section write the manufacturer direct or circle item numbers, cut out and mail this coupon. Prompt action is suggested so that data will be forthcoming without delay.

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BOX 2608, HOUSTON 1, TEXAS

Please have manufacturers send me, without obligation, additional information about items from May, 1951, New Equipment Section whose numbers are circled below:

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12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33
34	35	36	37	38	39	40	41	42	43	44
45	46	47	48	49	50	51	52	53	54	55
56	57	58	59	60	61					

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PLEASE PRINT OR TYPE YOUR COMPLETE MAILING ADDRESS

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 223, or write manufacturer direct.)

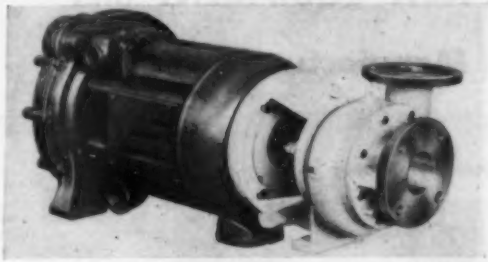
ing 100 psig. By employing special operating cams and rocker bars, the acceleration curve of one feeding head is exactly balanced by the deceleration curve of the second feeding head so that the resulting delivery from the two discharge ports manifolded into a common line is smooth and pulsation-free. Feed rate is manually adjustable; mechanism box encloses all moving parts in an oil bath. Bulletin 1245. Another bulletin (1923) describes "Pee Wee" pump, Models E and H. This has a maximum capacity of only two cc per stroke and is designed for continuous or intermittent feeding of water treating chemical solutions and slurries against pressures up to 50 psig.

Function Plotter

7 Automatic compiling of two measurements and plotting of a curve to show their inter-relationship, is made possible by a new electronic instrument, the Brown ElectroniK Function Plotter, developed by Minneapolis-Honeywell Regulator Company, Brown Instruments Division, Wayne and Windrim Avenues, Philadelphia 44. Brown engineers claim it incorporates two measuring systems, one of which actuates the recorder pen while the other motivates the instrument chart, driving the chart up and down in response to the changes in one variable simultaneously with the movement of the pen in response to changes in a second variable. Result of such action is a curve which continuously evaluates one variable in terms of the other. Laboratory or over-all industrial investigations involving such interdependent nonlinear variables are greatly facilitated with the Function Plotter according to the manufacturer.

Steam Turbine Pump

8 Installation and operating advantages of the TL Bilton design are available to steam power users with this new steam turbine driven model according to Byron Jackson Company, Pump Division, P.O. Box 2017, Terminal Annex, Los Angeles 54. This new addition to the B-J pump line is a combination of standard TL Bilton pump sizes with one of two Moon steam turbines. The two steam turbine sizes used have both the same shaft extension and rabbitt fit so that one standard TL Bilton connector and shaft sleeve is used with all pump and turbine combinations. Space requirements are small and no rigid foundation is necessary to install the close-coupled unit. It can be mounted at any angle and is said to be compact and light in weight. Sizes are one and one-quarter to three inches with capacities to 600 gpm; heads to 320 feet.



Water Softeners

9 Cochrane Corporation, Philadelphia 32, manufacturers of water conditioning equipment and steam specialties have issued Publication 4530, "Cochrane Hydrogen Zeolite (Cation Exchange) Softeners." Bulletin gives description of the process and field of application, showing the advantage claimed for hydrogen zeolite softening and its relation to the sodium zeolite softening process, as well as explanation of the zeolites themselves and details of equipment used in the process.

Industrial Piping

10 Crane Company, 836 South Michigan Avenue, Chicago 5, announced a new edition of its Piping Pointers manual and also offers a Piping Pointers film for use in training beginners and refreshing veterans in industrial piping crews. The manual covers the fundamentals of sound piping practices in easy-to-grasp, non-technical langauge. It discusses the various types of valve designs and how each should be used, and illustrates and names more than 80 kinds of fittings. More than half of the manual is devoted to "how-to-do-it" features. The Piping Pointers film is a 30-minute, 16 mm. sound film that dramatizes the information in the manual. Copies of the manual and free showings of the film are available.

Adhesive Signs

11 Self-adhesive "Quik-Label" safety signs are made by W. H. Brady Company, 1602 E. Spring Street, Chippewa Falls, Wis., who also manufacture Quik-Label wire, pipe and conduit markers. The signs are printed on extra strength cotton cloth with a self-adhesive backing. Each message is shown in large bold letters on proper safety background color and the sign is coated with silicone plastic to protect it from dirt, grime, and weather. The signs are easily removed from dispenser cards and quickly applied to chosen surface without moistening. Some 550 different signs and pipe markers are available.

Pressure Generator

12 A new "aiROYmetric" pressure generator manufactured by Milton Roy Company, 1302 E. Mermaid Lane, Philadelphia 18, is combined with a group of specially designed simplified controls to develop test pressures up to 25,000 psi., using ordinary

More Data — and Fast!

For additional information on New Equipment items or literature mentioned in this section, use the coupon on reverse side. Or write to manufacturer direct at address shown.

Act today!

PETROLEUM CHEMICALS DIVISION

NEWS

May ★ One of a Series of Interest to the Petroleum Industry ★ 1951

Petroleum Laboratory Finds Copper Present in Commercial Gasoline Samples

Du Pont's Petroleum Laboratory at Deepwater, N. J. recently checked thirty-three samples of commercial gasoline for copper content and found the element present in seventeen of the samples. The table below shows the geographical distribution of these samples together with a range of copper content observed:

	No. of Samples	*No. with Copper*	*Range of Copper Content in p.p.m.*
Phila.	7	2	.06 to .12
Tulsa	5	2	.06 to .12
Chicago	8	3	.05 to .21
Los Angeles	6	4	.05 to .13
Houston	7	6	.02 to .09

The analyses were conducted by the colorimetric method which will detect copper whether it is deactivated or not. As a result, the data do not indicate how many of the contaminated samples contained deactivator.

Automotive Technologist Specializes in Analysis of Engine Operational Problems

IVER T. ROSENLUND, who came with Du Pont in 1947, is the company's automotive engine specialist for the analysis of operational problems encountered in automotive equipment including farm tractors and heavy-duty trucking units. He was formerly Manager of the Du Pont Road Test Laboratory which operates a fleet of test trucks out of El Monte, California. Mr. Rosenlund is available to automotive equipment manufacturers, fleet operators and others who wish to make use of his extensive experience.

Mr. Rosenlund graduated from the University of Michigan in 1937, with a Bachelor of Science degree in aeronautical engineering, majoring in engine design. He spent the first few years of his career in aircraft engine testing and the development of automatic machine tools for the manufacture of aircraft engine parts. He has been actively engaged in problems of combustion and lubrication of engines since 1939 when he became a research engineer on engine testing for the development of petroleum products for the Texas Company in its research laboratory at Beacon, New York.

Between 1942 and 1947, Mr. Rosenlund was fuel and lubrication engineer for Allison Division of General Motors and later joined the Packard Motor Car Company in the jet-engine division at Toledo, Ohio, as project engineer on combustion chamber design and development.

Du Pont Truck Fleet Develops Valuable Heavy-Duty Road Test Data

What would you think of a fleet owner who gave his drivers instructions to take a load of gravel on a 208 mile jaunt and to return without delivering the cargo? Yet this is what happens regularly to each of six identical semi-trailer combinations operating out of the Du Pont road test laboratory at El Monte, California.

Shown are two of the fleet of six trucks used by Du Pont to make commercial, heavy-duty road octane tests. Each truck grosses 26,000 pounds on every trip. The terrain at this point appears rugged.

In evaluating the performance of experimental antiknock fluids prior to release for consumer use, laboratory testing is not enough. That is why Du Pont operates a six vehicle, heavy-duty, commercial test fleet under severe overload conditions on the hill and desert highways around Los Angeles.

A typical test might cover as much as 35,000 miles. As would be expected, much information is developed. Included would be information on octane requirements; valve life; cylinder bore wear and piston ring wear; fuel and oil consumption; and data on sludge and varnish deposits.

Here are some of the interesting characteristics of the fleet which travels without destination, delivers no load, yet brings back highly significant information.

The six tractor-trailer combinations are identical in every way, including their 235 cubic inch valve-in-head engines. The body of each trailer is partitioned to prevent shifting of the gravel which is used to weight the vehicles. This precaution is necessary to maintain a constant load on the tires which often are experimental tires being service-tested by the Rubber Chemicals Division of Du Pont.

The six vehicles always travel in convoy. They gross 26,000 pounds each. This weight corresponds to a sixty per cent overload for the tractor rating. With this loading, full throttle operation is required over most of the

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT

PETROLEUM CHEMICALS DIVISION
NEWS

DU PONT

Refinery Calls in Du Pont Automotive Specialist to Solve Annoying Problem

Fleet Customer Blamed Trouble on Refiner's Fuel

An Eastern District customer of Du Pont had complaints of engine sludging and heavy deposits on intake ports and valves from a fairly large fleet using its products. As is often the case, the refiner's products were blamed.

The refiner asked one of Du Pont's automotive specialists to investigate. He contacted the fleet owner, accompanied by refinery representatives. Several days were consumed in discussing the problems and in examining the fleet units and their operational patterns.

Both passenger cars and trucks were involved. Daily mileages were low, ranging from 40 to 100 miles. There was little prolonged heavy-duty work. Much of the operation was under conditions where engines were never completely warmed up in the course of a day.

Lengthy round-table discussions ended in the conclusion that most of the vehicles were subjected to unfavorable operating conditions such as prolonged idling and low output operation, with short hauls, frequent shutdown, and subnormal operating temperatures. These operating conditions, plus too infrequent oil change periods, were considered to be sufficient to cause the crank case sludging and intake valve troubles reported. Remedial recommendations were made and carried out to a satisfactory solution of the problem.

From the above it will be seen that Du Pont can contribute both knowledge and experience to the solution of a problem in the field. In such matters Du Pont will cooperate wherever it is feasible to do so.

Du Pont Offers *New Blending Calculator*

(AVIATION MIX)

A slide calculator for easy determination of the number of pounds of Du Pont Tetraethyl Lead Compound — Aviation Mix required for a given quantity of gasoline, is available through Du Pont Petroleum Chemicals Division District Offices.

The calculator is designed as a time-saver for blenders, chemists or others engaged in blending tetraethyl lead compound with gasoline.

Convenient in size, 9" x 4½", the calculator easily fits into a desk drawer or a coat pocket. With it, one can calculate the pounds of TEL Compound required to treat a given number of barrels of gasoline to produce concentrations from 0.1 to 4.6 cc. of TEL per gallon.

The calculator is quickly set in one operation.

This extremely handy Du Pont TEL Compound (Aviation Mix) Blending Calculator can be supplied by the nearest Du Pont Petroleum Chemicals Division District Office.

LITERATURE AVAILABLE

The following is a partial listing of free Du Pont bulletins, reports, booklets and aids available to you. Address requests to your nearest Du Pont Petroleum Chemicals Division District Office.

Du Pont Services to the Petroleum Industry . . . . . Serial A-663

Exhaust Valve Rotation—covers the use of mechanical devices to improve valve life . . . . . Serial A-656a Pet.

Du Pont Gasoline Antioxidants Nos. 5, 6 and 22—describing their use and application for improving gasoline storage stability . . . . . Serial A-513

The Effect of Hydrocarbon Structure on the Road Antiknock Performance of Motor Fuels . . . . . Serial A-505

Tank Talk—a 52-page pocket-sized booklet written for the men who actually enter and clean gasoline storage tanks . . . . . Serial A-1134

CONTINUED *Truck Fleet*

test route. The trucks are operated for sixteen hours per day.

The drivers and positions of the trucks are rotated daily to overcome variations which might be caused by differences in driver techniques. Drivers try to treat all trucks alike even in such minor details as braking, shifting and accelerating.

The route presents a normal intercity truck route winding through the foothills and mountains near Los Angeles. There are steady upgrades at full throttle, rolling downgrades requiring closed throttle positions and considerable stop-and-go driving in cities. The 208 mile course requires an eight hour shift per circuit.

Engines are operated at three-quarter to full throttle approximately seventy percent of the time. Average speed is thirty-seven miles per hour—maximum is fifty-five.

Since findings from the operation of this fleet are too detailed to be presented here, the principal purpose of this résumé is to suggest that there is considerable value in fleet work of the type outlined as a reproducible method for investigating differences resulting from fuel variables.

It is believed that experimental compounds which show promise in convoy operated tests can be released for further proof testing in commercial operations with considerable assurance of satisfactory performance. The tests also show that uniformly good performance can be obtained by paying close attention to maintenance techniques.

For more complete data on the findings address your nearest Du Pont Petroleum Chemicals District Office.

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IN CANADA: Canadian Industries Limited — Toronto, Ontario — Montreal, Quebec

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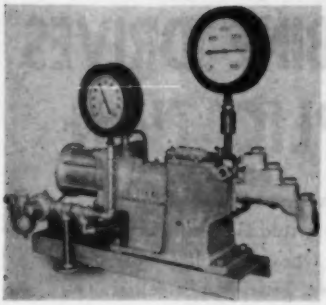


plant air supply in the pump cylinder. Each pump develops a discharge pressure ratio range of at least six to one, permitting single pump use for applications requiring various test pressures. (Manufacturer will custom build units for applications between 25 psi. and 25,000 psi.) The manufacturer recommends the pressure generator for use in hydrostatic testing of boilers, forgings, castings, tubing, etc., or it can be used as a booster pump for maintaining required pressures in hydraulic systems. Capacities range from 4 to 405 gph. pressures from 25 to 25,000 psi. with ordinary plant air supply. The self-reciprocating generator pumps at maximum capacity to build up desired pressure in the system and stops automatically when a balance is reached between air pressure and corresponding hydrostatic test pressure. Double-ball Check Liquid Ends are non-clogging and self cleaning.

Industrial Clothing

13 Shirts, trousers and coveralls made of Union Carbide's new staple fiber, dynel, is according to customer reports received by Chem Wear, Inc., 740 Broadway, N. Y., reducing clothing replacements in acid and caustic plant operations by as much as 75 percent. These reports and comparative tests of dynel clothing versus cotton and wool garments in aluminum chloride, zirconium and titanium tetrachloride departments of Stauffer Chemical Company, attest to the fabric's resistance to chemicals and to longer wearing qualities reports the manufacturer. Reported to feel like flannel, it is said to remain acid and caustic resistant permanently.

Steel and Copper Alloy

14 Lunkenheimer Company, Box 360-AA, Cincinnati 14, has available two brochures describing cast steels and copper base alloys in valve manufacture. These booklets offer solutions for piping problems and conservation of critical materials through getting maximum service from equipment. They deal with the basic problems of metal soundness, porosity, welding, graphitization, creep strength, new alloys, code conformance and other subjects.

Heat Exchangers

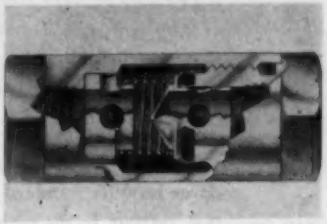
15 "Vogt Film Type Heat Exchangers, Bulletin HE-7" is offered by Henry Vogt Machine Company, Louisville 10. These heat exchangers

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 233, or write manufacturer direct.)

are of vertical, single tube-pass design with water falling in a film on the inside surfaces of the tubes. Because the water falls by gravity a good velocity is obtained with small quantity and with only one tube-pass, according to information from Vogt. Units are usually left open at the top and bottom to allow tube side cleaning while in operation. Vogt says the unit will perform its cooling function even when dirty water is used.

Low-Pressure Valve



16 A check valve for low-pressure application is being manufactured by James-Pond-Clark, Pasadena, Calif. Designated as Series 119, the valve is based on the firm's patented "Circle-Seal" principle, and is designed for low-pressure pneumatic or gas sys-

CHIKSAN MARINE & BARGE HOSE

LIGHT WEIGHT • EASY TO HANDLE

With the CHIKSAN aluminum Marine & Barge Hose, dock-to-vessel connections can be made by one man in just a few minutes. When not in service, the hose easily and quickly folds into a compact unit, without requiring disconnection from the Dock Riser. The same hose can be used for both suction and discharge.

MANY EXCLUSIVE ADVANTAGES

The CHIKSAN Hose, when used as shown, saves time, labor and expense, as well as dock space, and permits free movement of other equipment.

CHIKSAN Marine & Barge Hose, being made of metal, is not affected by severe climatic conditions or by petroleum products which may cause other hose to deteriorate rapidly. For the same reason, this all-metal hose is not subject to kinking, crushing or cutting—thus outlasting other hose.

CHIKSAN Marine & Barge Hose can be supplied in any required length and size, with end connections as specified, in either aluminum or steel, for above-surface or underwater service.

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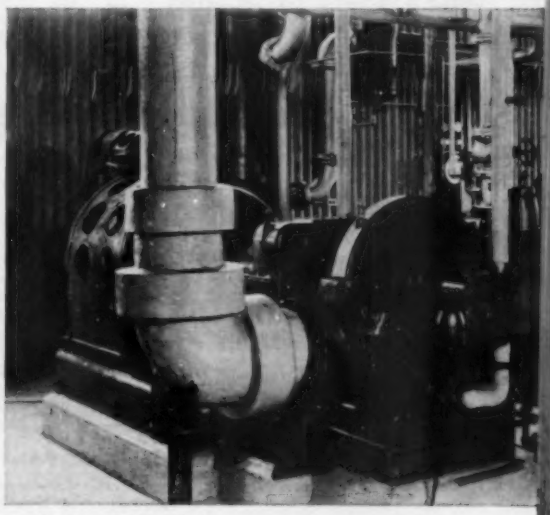
WHY STANDARD DP TURBINE DRIVES FIT ALMOST ANY APPLICATION

Here's a turbine designed by turbine users. It incorporates the features asked for by hundreds of operators interviewed in an exhaustive survey. They told General Electric they wanted a mechanical-drive turbine that would fit many types of applications—continuous process, standby, indoor, outdoor, equipment drive, generator drive, etc.

The DP answers these varied requirements with special features that are included as standard parts. For instance, you get hydraulic governing to meet critical accuracy requirements, totally enclosed construction that allows installation in hazardous atmospheres, pressure lubrication for dependable, continuous operation. These advantages are included at no extra cost—the DP is priced as a standard.

If you have steam available, the DP turbine can work profitably for you. You'll discover how its standard design gives you wide application flexibility, makes possible real savings in maintenance costs. The DP's operating record proves its reliability when there's a tough job to be done.

OUTDOOR INSTALLATIONS—No need to make special modifications when you move a DP out of doors. Totally enclosed governing system operating in its own oil atmosphere eliminates possibility of rusting or corrosion. You can operate a DP in hazardous atmospheres. Positive acting, non-sparking emergency governor protects the DP turbine against overspeed.



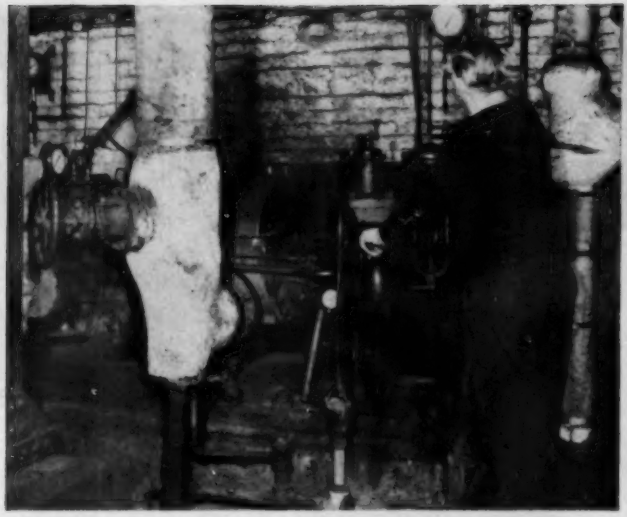
PRECISION GOVERNING—accurate enough for generator drives—is yours with the DP's hydraulic system. Regulation is 6 per cent with a 30 per cent range of speed adjustment. For process governing, regulator control is available.

Ask your General Electric representative for full details about the DP mechanical-drive turbine, or write for bulletin GEA-4955. General Electric Company, Schenectady 5, New York.

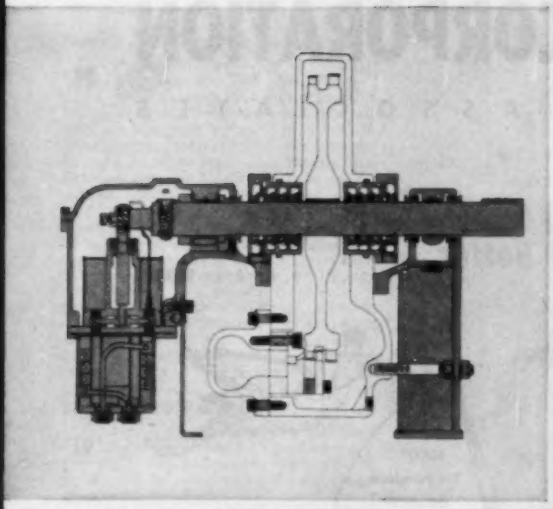
GENERAL ELECTRIC

252-50

MECHANICAL-DRIVE TURBINES



DEPENDABILITY is built into the DP. Positive lubrication through automotive-type bearings adds years to the life of the turbine. Special steel nozzle plate, self-lubricating graphite packings, and Monel-sprayed shaft are examples of design features that spell reliability.



APPLICATION FLEXIBILITY As the shaded parts in the diagram illustrate, most DP parts are identical on all frame sizes and ratings. In this way, you can adapt a DP for different job requirements with only minor changes. A different nozzle plate gives you a new horsepower output. A change in governor gears provides a new speed range. DP's are rated from 10 to 1200 HP and 1000 to 5000 rpm, and with slight modification, can deliver up to 2000 HP and 10,000 rpm. During a change in plant operation, the DP's flexibility will save you money.

EASY MAINTENANCE Because most parts are interchangeable on all models, spares can be stocked at low cost. A spare parts kit, containing 91 items, can be obtained with the turbine. This simple method of stocking spares lowers maintenance costs and provides protection for several DP's in your plant. All models, regardless of frame size, horsepower, or speed ratings, have identical shaft height, keyways, and coupling fits. Thus, installation problems are simplified; you can move these center-line supported units from job to job without a custom line-up.

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New Equipment

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tems. Cracking pressure is 4 to 8 inches water column; the valve "seals before the pressure across the poppet is equalized and will hold bubble tight against any back pressure within its rated range of 0-100 psi." Sealing is obtained by a poppet with a machined knife edge which is impressed into the surface of an "O" ring. In operation, the valve "will open instantly when flow starts, yet seals absolutely tight to prevent flow between units."

Liquid Level Gauges

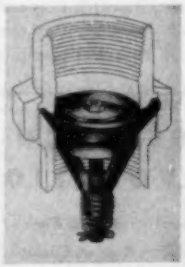
17 Bulletin, No. L700, on water level gauges has been published by the The Bristol Company, Waterbury, Conn. Float, pressure bulb, pressure, counterpoise, differential pressure, and air-bubbler types of liquid level gauges for a variety of uses are described, including the measurement and automatic control of water and other liquids and solutions, whether flowing, turbulent, corrosive, under static pressure, covered with ice, or carrying solid matter. Applications of the instruments to chemical processing operations are included. The bulletin also contains information on remote recording and remote automatic pump control of water level with Metameter telmetering instruments.

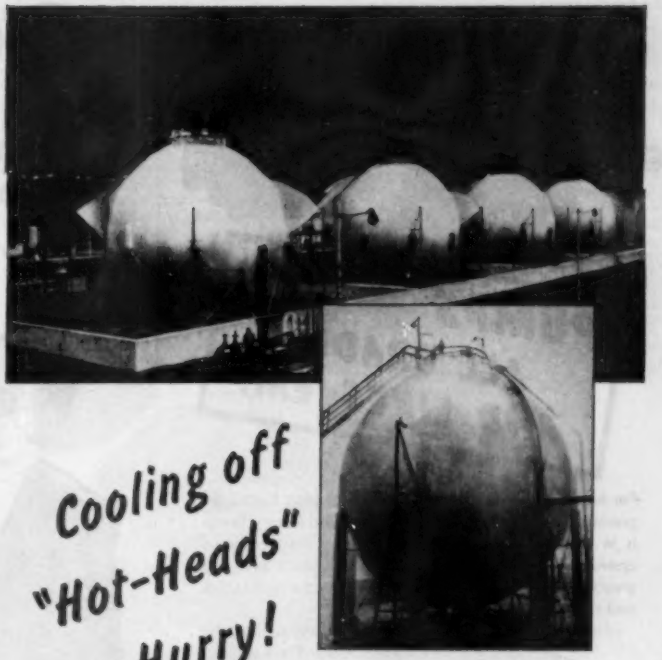
Flange and Coupling Selector

18 A revised edition of the Flange and Coupling Selector, designed by the Nooter Corporation, 1400 South Second Street, St. Louis, is available. In slide rule form, it provides the information contained in the earlier selector plus new data. The Flange Size Selector lists such relevant facts as the o.d. of flange, thickness, o.d. of raised face, number of holes, diameter of holes, diameter of bolts, bolt circle—for Series 15 and 30 Flanges. The Coupling Selector shows average sizes of standard, extra heavy, 3000-pound and 6000-pound couplings. A pipe standard table is incorporated on the selector, showing nominal wall thicknesses for Schedules No. 10 to 160 as well as nominal thicknesses and weight per foot for standard, extra heavy and double heavy pipe.

Union Check Valves

19 Union Check valve, manufactured by the Universal Valve Company, 555 Third Avenue, Elizabeth, N. J., is used in petroleum industry emergencies caused by a faulty angle or foot check valve. Installed within a standard union at the base of a gasoline pump above ground, the valve "eliminates suction line leak, and maintains a prime until repairs to the permanent installation can be made." Valve bodies and spring-action poppets are made of bronze, the

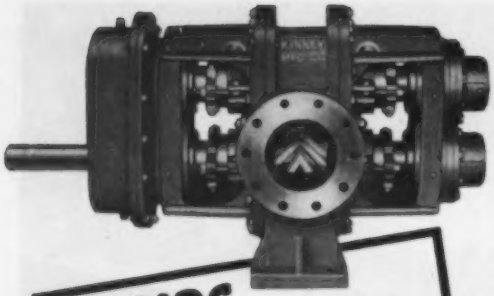




Cooling off "Hot-Heads" in a Hurry!

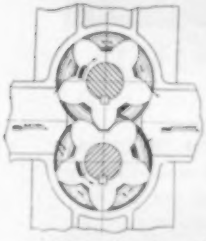
SHOULD normal temperatures rapidly rise to a dangerous point things happen fast around highly inflammable liquids—in fact, too fast for any fire protection system that doesn't go into immediate action! Blaw-Knox Sprinkler and Fog Nozzle Systems do just that. Actuated by rate-of-rise thermostats, they hit the hot spot with a quenching, cooling pattern of water that stops fire in its tracks. And do it with untreated water at normal pressures! Glad to give you a preliminary survey and estimate costs without obligation.

BLAW-KNOX SPRINKLER DIVISION
OF BLAW-KNOX CONSTRUCTION COMPANY
829 Beaver Ave., N.S., Pittsburgh 12, Pa.
Offices in Principal Cities



PUMPS ALL GRADES AND LIKES 'EM!

For handling all grades of crude oils at high discharge pressures, the Kinney Model HQ Heliquad Rotary Pump is in a class by itself. Even under the most rigorous operating conditions, this pump has what it takes to give faithful, efficient service at lowest cost for repairs and replacements.



Durability is designed into the Heliquad Pump. The pumping rotors are separated from each other and from the cylinder walls and heads by closely controlled clearances. The rotors themselves perform only one function – they pump liquids smoothly and efficiently. Hardened steel timing gears, in combination with anti-friction bearings, drive and synchronize the rotors and maintain the factory-built operating clearances for long and trouble-free pump life. Where required, pumps with renewable head liners are available.

Send coupon for complete details. KINNEY MANUFACTURING CO., 3596 Washington St., Boston 30, Mass. Representatives in New York, Chicago, Cleveland, Houston, New Orleans, Philadelphia, Los Angeles, San Francisco, Seattle, and foreign countries.

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Gentlemen:
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Refinery Executive: Do you actually guarantee performance?

Research Corp. Engineer: Absolutely. And you can depend on a Research Corporation guarantee because of Research Corporation's 38 years experience in electrical precipitation.

RC 130

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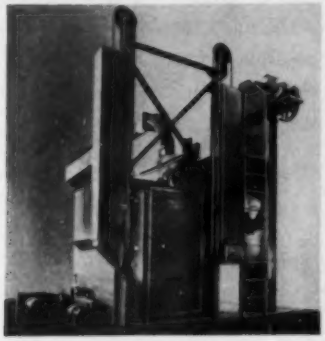
poppet seat is made of ferrous or nonferrous metals, synthetic or natural rubber, impregnated cork, or plastic. Valve bodies are 1¼, 1½ and 2 inches. No gaskets are required and the valve is easily removed from union for quick cleaning.

Rotoblast Machines



20 Rotoblast drum cleaning machines, Models ES-400 and ES-382, said to simplify and speed-up removal of dirt, rust, paint and other foreign materials from 30 to 55 gallon returnable steel drums and lids, are offered by Pangborn Corporation, Hagerstown, Md. Metal abrasive hurled against both the interior and exterior surfaces of drums scours the metal quickly, leaving no chemicals or alkalies to wash off, and providing a clean bonding surface for repainting. Drums are automatically handled during the cleaning operation. Machines will clean between 40 and 140 drums and lids an hour, variation dependable on the drum size. To prevent accidents, automatic shut-off valves prevent any flow of abrasive when the partitions or doors are open. Pictures and operation explanations available.

Liquijectors

21 Large volumes and high pressures of compressed air and other gases with contaminating water, free oil, water-oil emulsions and dirt are cleaned in a new series of Liquijectors, designed and manufactured by Selas Corporation of America, Erie Avenue and D Street, Philadelphia 34. The new Liqui-jectors deliver clean air-gas continuously to instrument or pneumatic systems through specially-prepared liquid-impervious ceramic filters. Liquids and dirt are ejected automatically. The devices do not have any moving parts.

Welding Plate

22 An all-plastic cover plate for welding helmet protective filter glasses is manufactured by General Scientific Equipment Company, 1015 Packard Building, Philadelphia. The cover plate is said to have a work life of 1000 hours. The manufacturer advises that GS 125 plate cuts down production costs because it will not warp, crack nor pit, but will offer clear visibility and fine optical qualities. Standard size 2 x 4¼ inches will fit welding helmets and hand shields.

Stainless Pipe

23 "Carpenter Stainless Pipe," a folder by Standard Brass & Manufacturing Company, 705 Milam Street, Beaumont, Texas, contains Schedule 5s, 10s, and 40s. These schedules encompass lightweight pipe for jobs involving light walls, middleweight pipe for use where pressure or strength requirements do not call for heavy walls, and heavyweight for application where maximum wall thickness and strength is required. Folder available.

Worm-Gear Valves

24 Worm and gear operated valves have been added to the line of Homestead-Reiser lubricated plug valves, manufactured by Homestead Valve Manufacturing Company, P. O. Box 550, Coraopolis, Penn.

Identified as Figure 502 GW, the new valves have the patented "Self Seald" construction characteristics of all Homestead-Reiser Valves; port area equivalent to 100 percent of the area of standard pipe; are cast in semi-steel, and made in 8, 10, and 12-inch sizes. According to the company, these valves will also be available in cast-steel, full-port type to be known as Figure 562 GW; and in venturi type sizes up to 14 inches. In the venturi-type these

New Equipment

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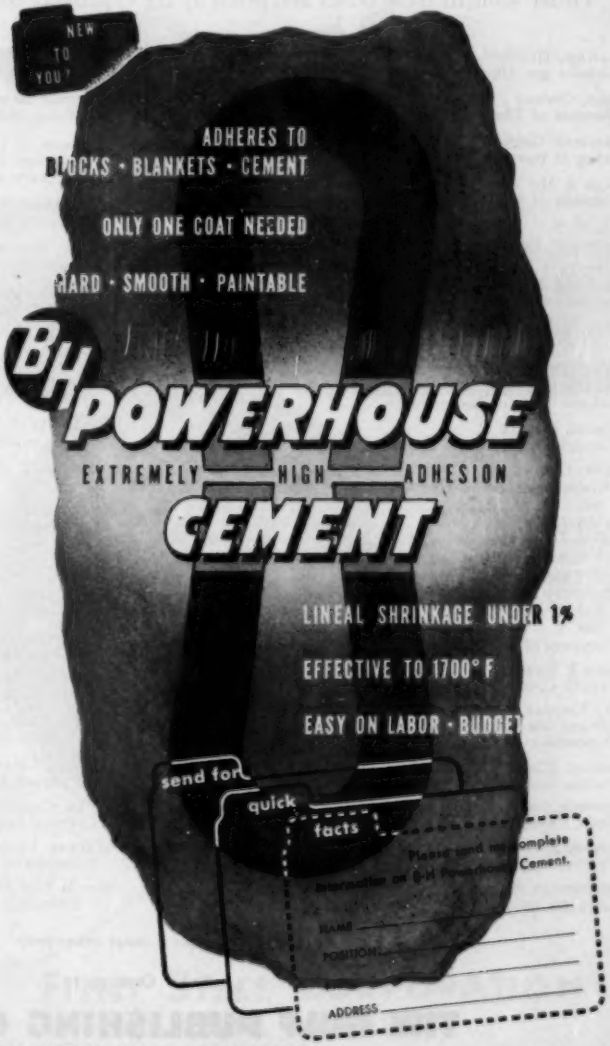

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valves will have face to face dimensions identical to those of like-sized series 15 wedge gate valves; and will be designated as Figure 512 GW for semi-steel, and Figure 572 GW for steel. Reference Book 39-5.

Pumps

25 Describing and illustrating a broad line of general purpose pumps, a new bulletin has been published by Peerless Pump Division, Food Machinery and Chemical Corporation, 301 West Avenue 26, Los Angeles 31. Peerless Fluidyne pumps are of the horizontal, end-suction centrifugal type and may be driven by electric motors in sizes from one-quarter to 150 hp, affording a capacity range from ten to 5500 gallons per minute. Liquids can be pumped against heads up to 260 feet. Two types of pumps are offered; a close-coupled electric motor driven pump, designated "PE," and type "PB," a bracket-mounted pump for driving through a flexible coupling, or V-belt, or flat-belt pulley. Bulletin B-2300.

Oil-Chemical Processes

26 A 40-page, pocket-size brochure, "Looking At Lion Oil Company," published by Lion Oil Company, El Dorado, Ark., describes Lion's operations in the oil and chemical industries. Part I describes in layman's language the operations involved in the manufacture of synthetic nitrogen, nitric acid, sulphuric acid and sulphate of ammonia. For the technically minded are listed the chemical reactions which occur in the various processing steps at the chemical plant and the catalysts which promote them. Part II describes Lion's 22,000-barrel per day capacity refinery and includes flow sheets and schematic drawings of the chemical and oil refining plants.

Masonry Blades

27 "How to Cut Blade Costs in Masonry Cutting," a booklet issued by Eveready Briksaw Company, 1509 South Michigan Boulevard, Chicago 5, is intended for use of contractors or operators whose profit or loss on a job might be determined by his knowledge of cutting and material facts. For instance, the booklet tells the operator how to run simple blade cost analysis tests before starting the job; and how to determine the correct abrasive or diamond blade to use on each different material.

Tube-Supported Wall

28 A new catalog on tube-supported walls for industrial boilers is available from Bigelow-Liptak Corporation, 2842 W. Grand Boulevard, Detroit 2. The catalog describes how Bigelow-Liptak walls may be suspended directly from boiler tubes with resulting savings in steel and erection time. Engineering drawings show typical jobs and describe how the enclosure is fastened to the boiler tubes. Of particular interest is the inside spread which shows a series of photos of a job being erected.

Expansion Joints

29 Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Del., has published Bulletin 351 describing the complete line of Zallea Expansion Joints. It gives sizes, dimensions, suggested applications and other technical data on a variety of joints from small flexible connectors for use on diesel exhaust lines to 30-foot diamter self-equalizing joints for use in such applications as wind tunnels, etc.

New Equipment

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Pump Brochures

30 "The Home of Sigmund Pumps" contains a description of the facilities and organization of Sigmund Pumps Ltd., Terminal House, 52 Grosvenor Gardens, London. Design, workmanship and performance of a

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New Equipment

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range of high standard equipment is pictured as well as the layout of the plant showing the particular thought given to requirements of process and chemical pump production. A second brochure illustrates a few representative installations picturing Sigmund Pump equipment in operation around the world.

Black Magic Gloves

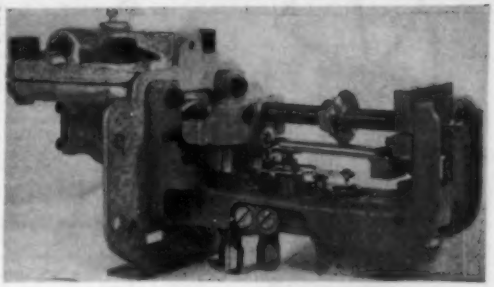
31 Plasticote Glove Company, Inc., Milwaukee 12, Wisc., has perfected a new plastic which is impervious to gasoline and hot oils as well as being resistant to acids, chemicals, corrosives, heat and flame. Black Magic plastic not only withstands rigorous tests but remains soft and pliable, according to the company. The gloves may be used in alkali solutions and as high as 40 percent ferric chloride solutions without deterioration.

Condenser Tubes

32 Revere Copper and Brass, Inc., 230 Park Avenue, New York 17, has issued an illustrated brochure, "Life Extension for Condenser Tubes," which reports its research on causes of corrosion and means of combating them. The company points out that copper and copper alloy restrictions have stressed the importance of extending condenser tube life and the booklet explains what Revere has done and is doing in the situation.

Differential Converter

33 A compact, lightweight transmitter, the Differential Converter designed by Minneapolis-Honeywell Regulator Company, Brown Instruments Division, Wayne and Windrim Avenues, Philadelphia 44, for more sensitive measurement and control of fluid flows in many industrial processes, has a continuously adjustable range from 0-20 to 0-200 inches of water (differential pressure) and provides this 10-to-1 change of range with no change of parts. Field calibration of any range is possible by use of scale-type weights which eliminate the need for a water column. Operating on the pneumatic-balance principle without mercury, the Differential Converter employs an accurate weigh-beam system in which the differential pressure, due to fluid flow at the metering orifice, is continuously balanced by a pneumatic pressure. This pressure becomes a measure of the fluid flow and is connected to a recording or controlling instrument. Extremely fast speed of response to rapid changes in flow is the prime feature claimed for the system. Forged unit body is offered with 750 or 1500 psi. rating in Type 316 stainless steel or carbon steel.



Cleaning of Ferrous Metals

34 Pennsalt's Special Chemicals Department, Pennsalt Chemicals, 1000 Widener Building, Philadelphia 7, has issued a service bulletin, "Heavy-Duty Alkaline Cleaning of Ferrous Metals," which describes approved methods for alkaline soak tank cleaning, alkaline spray cleaning and alkaline electrolytic cleaning, barrel cleaning, steam gun cleaning and manual (bucket-and-brush) cleaning of walls and floors. Procedures include recommendations for proper cleaners for specialized purposes.

pH Determinations

35 Analytical Measurements, Inc., 585 Main Street, Chatham, N. J., makes a pocket-size pH meter and companion probe unit which "per-

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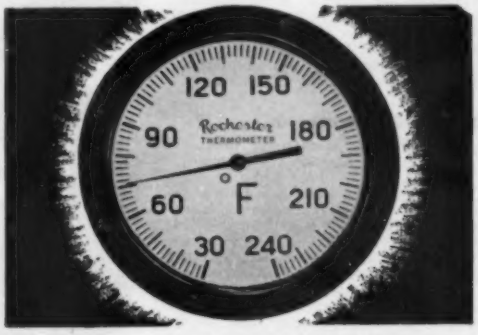

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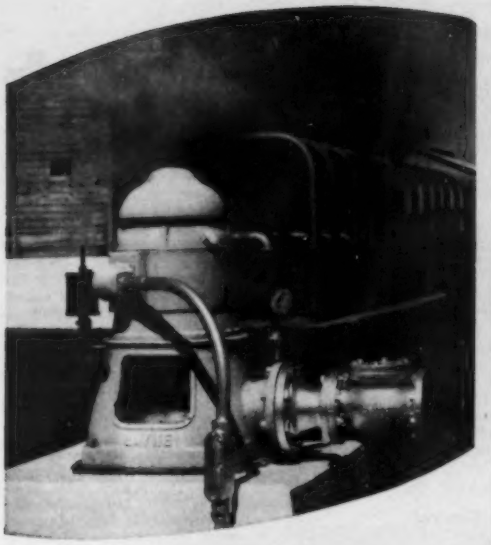

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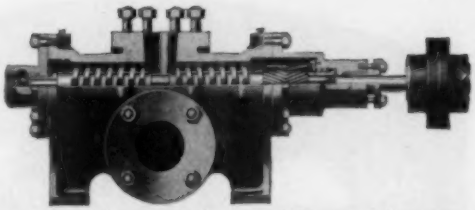
mits instant, on-the-spot pH determinations anywhere." Completely self-contained with batteries, in a bakelite case 3 x 5⅞ x 2½ inches, this instrument is furnished, camera fashion, with an ever-ready case with novel plastic tubes of buffer and KCl solutions. Total weight is three pounds. Calomel and glass electrodes in combination with the sample holder in a single polyethylene probe unit eliminate need of supports and beakers. Combining the sample holder with the electrodes is said to protect them and requires a sample volume of only 0.5 ml. Meter is scaled from two to twelve pH, simple adjustments give readings from 0 to 14. Hearing-aid type batteries give up to 1300 hours operation. One knob control and continuous reading features simplify operation for untrained personnel, says the manufacturer.

Quimby Pumps

36 Rotary Pumps, both Screw and Rotex types, are manufactured under the Warren-Quimby trade name by Warren Steam Pump Company, Inc., Warren, Mass. Each is available in external gear and bearing and gear-in-head construction and either vertical or horizontal. The screw pumps (pictured) are built in capacities up to 3000 gpm. and in pressures to 200 psi. on low viscosity liquids, and "for practically unlimited high viscosity liquids." Steam jacketed if desired. Rotex pumps have capacities up to 1000 gpm. and pressures to 250 psi. Maximum viscosity is 100,000 Saybolt seconds. A number of rotor widths are available for each pump size making it possible to get desired capacity at direct connected motor speeds.



Steam and Liquid Control

37 "Steam and Liquid Control Equipment" issued by O. C. Keckley Company, 400 Madison street, Chicago 6, contains illustrations and engineering data on precision pressure regulators, temperature regulators, float valves, water gauges, float boxes, safety and relief valves, strainers, etc. Drawings, layout diagrams, dimensions and capacity tables are included.

Steam Equipment Catalog

38 The C. E. Squires Company, 18502 Syracuse Avenue, Cleveland 10, Ohio, has published a 33-page catalog which contains descriptive matter on steam and air traps, pressure reducing valves, pump governors, pressure regulators, boiler feed controls and temperature regulators. Included are data for sizing this equipment, such as trap capacity tables, reducing valve selection charts, and reducing valve capacities.

Measuring Wheel

39 Rolatape Inc., Santa Monica, Calif., makes Model 400 Rolatape, a measuring wheel four feet in

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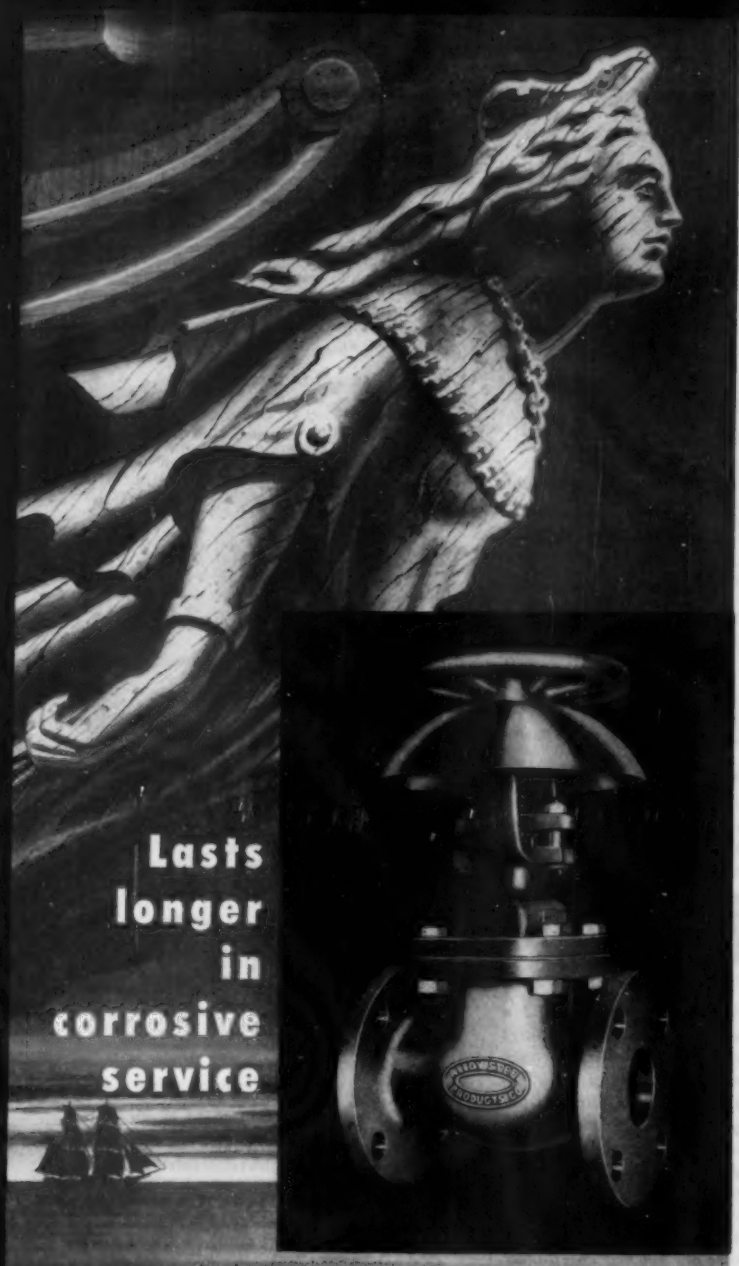
Wheelco instru*mentality* adds safety and product uniformity.

Write for Bulletin C2, Wheelco Instruments Company, 701 W. Harrison Street, Chicago, Illinois.

wheelco electronic controls



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THE CORROSIVE: acid sludge.

THE PLACE: Esso Standard Oil Refinery, Baton Rouge, La.

THE VALVE: ALOYCO Figure 1103 Hastelloy D gate valves. Field tests made by The Aloyco Corrosion Clinic clearly indicated that Hastelloy D would do the job. Problems of fabricating this hitherto unmachinable alloy were solved by Alloy Steel Company production men. Now Hastelloy valves are used in many applications such as Esso Standard's.

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Alloy Steel Products Company maintains the *largest* laboratory devoted *exclusively* to the "diagnosis" and "treatment" of problems relating to valves in corrosive service. From the results of laboratory and field testing, it develops the specifications for customers' applications.

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circumference, which registers distances up to 100,000 feet and then repeats the cycle. The wheel "does not sway in operation but tends to stabilize its course and follow a straight line, measuring and recording during the operation." The Model 400 weighs only five pounds and is easily operated by one man, or it can be operated by a driver in a car as he drives slowly over the course to be measured. The handle folds compactly for easy storage or transportation when not in use. A stand holds the wheel upright without losing count of distance while operator logs data.

Chamber Gages

40 Jerguson Gage & Valve Company, 80 Fellsway, Somerville 45, Mass., are manufacturing a Non-Frosting Large Chamber Gage, series RLF-10 (reflex) or series TFL (transparent) which incorporates the Jerguson patented gage glass extension which is claimed to prevent frost from forming over the vision slot and thereby permitting quick accurate level reading of low temperature and low boiling point liquids. The manufacturer says this gage is well adapted to the gaging of light, gaseous fluids that tend to boil or surge because of the larger area at the meniscus. Literature.

Aircomatic® Welding

41 A reprint of "Aircomatic® Welding of Copper Base Alloys," by Harold Robinson and John H. Berryman, has been released by Air Reduction Magnolia Company, P. O. Box 319, Houston. This article encompasses a general investigation into the weldability of several copper-base alloys with the recently developed inert-gas-shielded metal-arc welding process. Mechanical properties of a few simple welded joints with a number of electrode-filler metals and several practical applications are included. Copies Form ADR 69 available free.

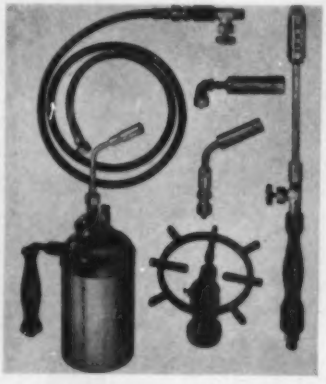
Plug Valves

42 Nordstrom Valve Bulletin, V-214, issued by Rockwell Manufacturing Company, 400 North Lexington Avenue, Pittsburgh 8, deals with piping, wiring, mounting, and installation data for power-operated Nordstrom lubricated plug valves and is said to be the first complete compilation of technical data covering the use of pneumatic, hydraulic and electric operators for lubricated plug valves. Included are typical piping diagrams, arrangements for both sides and top mounted motor controls, closing speeds, wiring data, and photos of installations.

Viscorator Instruments

43 Catalog "88" by the Fischer & Porter Company, 4030 County Line Road, Hatboro, Pa., describes Viscorator instruments that provide an instantaneous method for determining viscosity values for industrial processes. Featured is a new development in this field represented by the Auto-Sampling Viscorator instrument which has a constant differential pressure regulator as an integral part of its design. This provides a constant meter sample flow rate (regardless of line fluctuations) in a simple self-contained unit.

Portable Torch



44 An all-purpose portable torch that gives prompt heat-up to 2300° F. and is claimed to be clean, fast and efficient, is offered by Liquid Gas Equipment Company, Inc., 3600 West Imperial Highway, Inglewood, Calif. The torch requires no pumping, priming, pre-heating, blowing out, or waiting. Fingertip valve has positive needle-valve shut-off, the only moving part. Handle is heat insulated, and weighted base prevents tipping. Capacity .91 pounds propane or butane; ICC specifications. Comes equipped with coffee warmer attachment, tip assemblies for broad flame or blast-type flame, auxiliary hose for torch tip assemblies to be used up to four feet from the tank.

Recorder Chart Drive

45 A recorder chart drive that uses the regular instrument air supply as a power source is being manufactured by Air Clocks, Inc., Huntington Station, N. Y. The air clock, essentially the same size as conventional

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For 70 years we've been weaving Wire Mesh. And a good part of that time we have also been making things of Wire Mesh for people who find it is cheaper, easier and generally more satisfactory to "let Jelliff do it." From big Dipping Baskets to tiny precision filters—from fuel strainers to what-is-it gadgets—JELLIFF's Custom Production Department turns out fabricated Wire-Mesh products at speed, price and precision that mean lower costs and a stronger competitive position for our many customers.

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By permitting water, aqueous solutions or any volatile liquid to evaporate under high vacuum and without heat from an outside source, enough BTU's can be removed to chill the liquid down to 32° F., or even lower in the case of solutions. This is the principle of the Croll-Reynolds "Chill-Vactor." Hundreds of these have been installed throughout the United States and in several foreign countries.

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a FLORIDIN DESICCANT

The high-pressure dehydration unit here illustrated is a property of the United Gas Pipe Line Company at Carthage, Texas. It represents the most advanced design, construction, and operating technique; and the drying agent employed is FLORITE DESICCANT. The Stone & Webster Engineering Corporation, who designed and constructed the plant, are users of FLORITE in various types of equipment, large and small, for oil and gas companies and for other branches of industry.

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New Equipment

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electric units, is readily mounted within standard circular chart recorder and recording controller cases. The manufacturer asserts the new drive realizes a need for all pneumatic equipment in hazardous locations with the development of the air-run clock which eliminates electric conduit for the many chart drives.

TCC Catalyst Measure

46 The Gagetron is an atomic energy-operated device for measuring catalyst level in a Houdriflow catalytic cracking unit, manufactured by Brown Division, Minneapolis-Honeywell Regulator Company, Wayne and Windrim Avenues, Philadelphia 44. It was developed primarily for catalyst level control by Instruments Incorporated of Tulsa, and is applicable for the measurement of all liquid levels and fluid densities through container walls, eliminating seals, stuffing boxes, etc. The Gagetron operates on the principle that gamma radiations from a radioactive source vary in proportion to the density of any material between the radiation source and a detecting means, a Geiger counter.

Packings and Gaskets

47 Raybestos-Manhattan, Inc., Packing Division, Manheim, Penn., has published "Packings and Gaskets" which contains descriptions, service recommendations, standard sizes, standard package descriptions, and weights as well as photographs and some explanatory material about the complete line offered. In the back of the catalog are found conversion tables, steam table, table of water heads and equivalent pressures, a table of circumferences and areas of circles, tables of decimal equivalents and general information.

Laboratory Equipment

48 Scientific Glass Apparatus Company, Inc., Bloomfield, N. J., makers of laboratory apparatus, instruments, chemicals, and glassware, have issued "What's New for the Laboratory," Number 12, a supplement to its other catalogs. A number of new items, laboratory clamps of new design, a pail and dipper of special rubber-like material for handling corrosive chemicals, miniature type pumps, a handled beaker, a unique pocket-type thermometer, and other items are described.

Scaffolding Bulletin

49 Bulletin PSS-24, published by The Patent Scaffolding Company, Inc., 38-21 Twelfth Street, Long Island City 1, N. Y., shows pictorially the advantages of "Trouble Saver" sectional tubular steel scaffolding for maintenance work in industrial buildings. Detailed information on erection and dismantling of basic units, building up complete assemblies, available frames and components and a wide variety of actual applications of a special nature are presented along with many on-the-job applications.

Air Pumps

50 A new line of air-operated material handling pumps is manufactured by Binks Manufacturing Company, 3112 Carroll Avenue, Chicago 12. These pumps, say the manufacturer, handle all fluids from thinners, lacquers, and paints to adhesive, sound deadeners, heavy roofing material, asphaltums, and protective coatings of every kind, even those containing abrasives. Binks pumps deliver materials to the guns under controllable hydraulic pressure, and the high pressures possible make it practical to pump many materials considerable distances from supply drum to gun according to Binks. They can be used to transfer materials from one container to another, or for mixing operations. Bulletin 700.

Portable Oxygen Unit

51 A portable model of the M-A-S oxygen therapy unit has been introduced by Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8. Capable of supplying oxygen needs for one person for approximately 90 minutes, this new instrument is mounted on a lightweight metal frame with a clamp and leather handle for ease in handling. The complete unit consists of a half-mask facepiece, pressure regulating assembly, flexible breathing hose and a 40 cubic foot capacity oxygen cylinder. Bulletin CW-6.

Lens Tissues

52 A new, large size, silicone treated lens tissue and compact dispenser is made by American Optical Company, Safety Products Division, Southbridge, Mass. Designed to keep safety goggles clear, clean and polished, the tissue is 5 x 6¾ inches in size and is packed 800 to a packet; six packets to a carton. Silicone treated tissues "remove dust, dirt, lint and smears and deposit an invisible coating of silicone to make each cleaning last longer." The dispenser is of 20-gauge steel, has no moving parts and is supplied complete with four mounting screws and sturdy lock. It allows removal of only one sheet at a time.

Silica Removal

53 A new folder emphasizing silica removal by Amberlite deionization has been prepared by Rohm & Haas Company, Washington Square,

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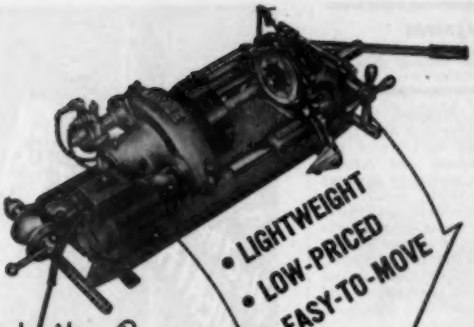

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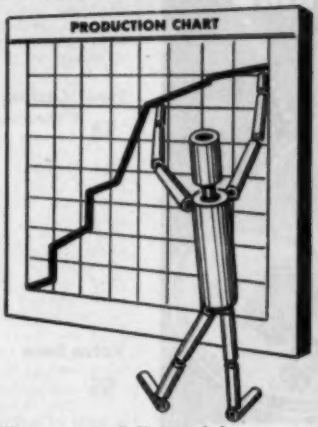

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Philadelphia 5. It is designed to help the power plant engineer and the chemical engineer generally to evaluate the usefulness, applications and recommended layout of ion exchange systems to provide water practically totally free from hardness, carbon dioxide and silica. Text explains what results may be expected from Amberlite Monobed (single bed) as well as multiple-bed systems; describes how deionization works; and suggests typical uses in the process and power industries. Title "Zero Hardness by Amberlite Deionization."

Steel Casting

54 "The Steel Casting Industry," a booklet published by Steel Founders' Society of America, 920 Midland Building, Cleveland 15, and intended to serve primarily as a guide for engineers, management executives and students, has been made available again. The booklet uses graphic case history examples to demonstrate the versatility, strength and dependability reflected by steel castings performance. Emphasis is on production economy and adaptability to complex design requirements.

Valve Data

55 "Valve Values," a sales and service publication of Edward Valves, Inc., East Chicago, Ind., contains a table of welding and specifications for Edward cast steel valves, diagrams of straight bevels for pipe wall thicknesses, diagrams of U-bevels for pipe wall thicknesses, and an article, "Welding Standardization," by L. H. Carr, research and engineering director of the company. The welding end specifications is a reference table developed from specifications of the American Steel flange standard B 16e of 1939, the ASA B 31.1 1951 Code for Pressure Piping, the ASME Power Boiler Code of 1946 and Pipe Fabrication Institute Standard ESI, 1948. It is designed for handy desk top reference.

Spray Gun

56 Schori Process Division, Ferro-Co. Corporation, 8-11 43rd Road, Long Island City, has developed a special spray equipment that sprays

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two solutions at the same time. The gun was developed to handle materials that are stable in themselves but that cure quickly when mixed with other materials. Formulations can be sprayed that will be tack-free in ten minutes. The Schori unit uses two pots and a spray gun with two nozzles, an arrangement that keeps the solutions separated until they are mixed "externally" as the material is atomized. This method permits longer pot life.

Computer Selects Alloys

57 A handy pocket-sized computer that quickly tells which non-ferrous or stainless steel alloys to use for 142 corrosive situations is offered by the H. M. Harper Company, 8200 Lehigh Avenue, Morton Grove, Ill. The computer is printed on paper board and operates like a slide rule. The inner member is moved to line up the corrosive agent with a large arrow. A window then rates 13 non-ferrous and stainless steel alloys as excellent, good, fair or not good for this agent. This computer is helpful in the choice of substitute materials when the non-ferrous or stainless steel alloy usually used is unavailable.

Trackmobile

58 A brochure picture story on the Trackmobile is available from Whiting Corporation, Harvey, Ill. The Trackmobile substitutes pounds of hydraulic power in place of mass and weight alone, it operates on the track or ground, weighs only 6000 pounds yet develops a draw-bar pull equal to that of larger conventional plant locomotives through use of hydraulic jacking. The Trackmobile raises the coupling of the car just enough to transfer some weight onto the Trackmobile, developing needed adhesive force. Has wheels for track travel and rubber tired wheels for ground operation which are hydraulically retracted when machine moves onto the track. Flexibility prevents bottling up after completion of hauling job.

Roller Conveyors

59 Spark-proof portable conveyers for use in munitions plants, paint factories, or other set-ups where explosive dust or fumes create hazards are manufactured by the Samuel Olson Manufacturing Company, Bloomingdale Avenue, Chicago 47. The frame is steel with hard maple rollers and hard maple sideguards which extend about an inch beyond the frame and over the rollers. Materials moved on the conveyor cannot strike the steel frame and cause sparks. The rollers are fitted with hexagon shafts equipped with ball bearings; brass ferrules at the ends of each roller are said to prevent splitting. Heavy duty type casters, ball bearing wheels, ball bearing swivels, and wheels with rubber tires are other specifications.

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 222, or write manufacturer direct.)

Gratings, Treads, Linings

60 A concise, factual bulletin giving full details on riveted and welded types of open steel grating for walkways, platforms and similar applications, also on numerous types of open steel stair treads, can be obtained from Wm. F. Klemp Company, 6621 South Melvina Avenue, Chicago 38. The various types and designs of gratings and stair treads, also types of tread nosings, are fully illustrated, accompanied by detailed drawings which include all dimensions of openings, spacings and sizes of members. The bulletin also gives practical information on two types of steel reinforcement mesh extensively used for ganister or concrete protective linings of cylindrical vessels, such as fractionating towers or crackers.

Refinery Products

61 The mechanical goods division, United States Rubber Company, Rockefeller Center, New York 20, has published a new catalog containing engineering data on the division's line of oil, gasoline, liquefied petroleum gas, water, steam and air hose used in refinery operations. Given also are data on its various types of packing materials and expansion joints. A section is devoted to its new Uscolite thermoplastic pipe, the chemical resistance of which makes it particularly suitable to refinery work.

Chemical Refining of Petroleum

By VLADIMIR A. KALICHEVSKY
Research and Development Laboratories, Socony-Vacuum Corpn. Author of "Modern Methods of Refining Lubricating Oils"
and BERT ALLEN STAGNER, Ph.D.
Consulting and Research Chemist; Member, American Institute of Chemical Engineers; Formerly: Supervisor Chemical Research, Union Oil Company of California; Research Fellow, Mellon Institute of Industrial Research

American Chemical Society Monograph, No. 63
Second Edition, Revised and Enlarged

The rapid development of petroleum technology has necessitated a revision of the original volume published in 1933. The newest practice in regard to treatment with sulfuric acid, tetraethyl lead, octane rating, etc., is described in detail. The present emphasis on all phases of this vitally important subject makes this book a particularly timely one, especially since the petroleum problem today is rather one of refining capacity than of crude production. For this reason technical improvements are of the utmost importance for the pressing problems of national defense.

CHAPTERS

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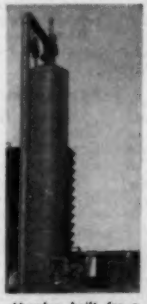

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Liquid Extraction

Liquid Extraction, Robert E. Treybal, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, $7.50.

A seemingly complete review and organization of subject matter related to unit operation of liquid-liquid extraction. Physical chemistry of liquid-liquid equilibria, prediction of equilibria, thermodynamics of nonideal solutions, choice of solvent, diffusion in liquids, theoretical discussion of mass transfer, design of extraction systems, description of equipment and operating characteristics and a brief review of important modern chemical processes using liquid extraction, being among the matters discussed.

Suggested by McGraw-Hill as a basis for formal teaching because of comprehensive coverage of subject which has been rather ignored by publishers to this time.

Chemical Lime

Chemical Lime Facts, National Lime Association, 925 Fifteenth Street, N. W., Washington 5, D. C. Complimentary copies.

Written expressly for chemists and chemical engineers in lime consuming industries, and intended for permanent reference material, the bulletin is divided into two main sections:

Discussion of many diverse chemical lime uses, divided into the following categories: metallurgy, pulp and paper, chemicals, water treatment, sewage-trade waste treatment, ceramic products, building materials, protective coatings, food and food by-products, and miscellaneous uses.

Technical data section on principal chemical and physical properties of lime, including data on solubility, pH, strength of lime suspensions, specific vents, crystalline structure data, and neutralization values.

I. G. Farben Review

Studies on Synthetic Lubricant Oils, (PB 101 870), Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., 50 cents, payable Treasurer U. S.

A report prepared by the Defense Department's Central Air Documents Office, is a description of studies of development of synthetic lubricant oils carried on by I. G. Farben's division of High-Pressure Experiments, beginning in 1924 and culminating in World War II developments.

Included is a description of the chlorine method of lubricant-oil synthesis, giving the percent yields of various oils; a discussion of the paraflow synthesis and its application to lubricant oils with solidification points from minus 10° to minus 30° C.; and a review of the synthesis of lubricant oils from propylene by polymerization with $AlCl_3$. Properties of propylene oils are given, as well as results of engine tests.

Screwed Fittings

American Standard Malleable-Iron Screwed Fittings, 300 Pound, B16.19-1951, American Standards Association, 70 East 45 Street, N. Y. 17, Free.

This is companion to a document of the same title, 150 Pound, B16c-1939 volume. The 300-psi. fittings are used primarily for very severe piping applications in the petroleum industry; for oil and gasoline lines; for railroads, ships, and diesel engines; and for steam at high pressures. Pressure-temperature ratings are listed, also dimensions for elbows, tees and crosses, center to-end dimensions of 90-degree elbows and tees, and dimensions of couplings, reducing couplings, caps, street elbows, and return bends.

This standard was developed by a committee organized under American Standards Association procedure and jointly sponsored by the American Society of Mechanical Engineers, the Manufacturers Standardization Society of the Valve and Fittings Industry, and the Air Conditioning Contractors National Association.

Research Findings

Fundamental Research on Occurrence and Recovery of Petroleum, Volume IV, Research Projects, J. A. McNally, American Petroleum Institute, 50 West 50th Street, New York 20, $6.

The new volume is a compilation of data resulting from a series of eight different investigations conducted by American Petroleum Research Projects 27, 37, 43, and 49 during 1948 and 1949. Volume also contains 20 papers which give results of several projects, most of which have been published from time to time. The volume compiles all this data into convenient reference form.

The projects on fundamental research, sponsored by the Committee on Research of the Board of Directors of the Institute, are directed by research advisory committees and are financed by private subscription. Copies of the 1943, 1944-45, and 1946-47 volumes also may be obtained through McNally.

Petroleum Production

Oil and Gas Production, Engineering Committee, Interstate Oil Compact Commission, P. O. Box 3127 State Capitol, Oklahoma City 5, $2.75.

This book is an introductory guide to production techniques and conservation methods and gives in lucid manner, and straightforward, easy language the important facts essential to maximum utilization of petroleum resources.

Critics say the volume is technically accurate and thoroughly comprehensive of its subject matter. Text has been written for understanding of layman as well as technician. Contains illustrations, charts, graphs and tables to simplify explanations of the processes used to recover petroleum.

Quality Control of Materials

American Society for Testing Materials *Manual on Quality Control of Materials* (STP No. 15-C), 100 pages, ASTM, 1916 Race Street, Philadelphia 3; $1.75 per copy.

Replacement for ASTM Manual on Presentation of Data, the new manual is organized into three parts. The first division represents a revision of the main section of the former manual, and discusses the application of statistical methods, condensation of n observation, and concise presentation of information.

Section two discusses the problem of presenting limits to indicate the uncertainty of the average of a unique sample of n observations. It also suggests a form of presentation for use in ASTM reports and publications. Working rules are presented regarding the number of places to be retained in computation and presentation of average, standard deviations, and confidence limits.

Part three presents formulas, tables, and examples useful in applying the control chart method of analysis and presentation of data. This method requires that the data be obtained from several samples or be capable of subdivision into subgroups on the basis of relevant engineering information.

Inform Your Employes

On Our Toes, (a slide-motion film) Oil Industry Information Committee of the American Petroleum Institute, 50 West 50th Street, New York 20, any committee district office, or the Western Oil & Gas Association, Los Angeles. $25 plus shipping charges.

"On Our Toes," a new slide-motion film aimed at informing the oil employe of the industry's current position, points out why the oil industry will be capable of meeting military requirements promptly—if circumstances do not restrict their basic freedom to adjust operations according to demand.

The film employs a new technique of partial animation, giving the effect of both slide and motion picture projection. Black and white, and running 13½ minutes in length, it requires only a standard 16 millimeter sound projector for showing.

Competition creates productive vigor, says the film, and accordingly, competition should be retained or disturbed as little as possible. It contains a recording of a speech by Secretary of Interior Chapman who said he would guard competitive relationships among the units of the oil and gas industry during the present emergency to the end that they would emerge in a healthy state for peacetime operation.

Gray Iron Coatings Manual

Metallic and Non-Metallic Coatings For Gray Iron. C. O. Burgess, Gray Iron Founders' Society, Inc., 210 National City—East 6th Building, Cleveland 14. $1.25 to members; $1.75 to others.

A new 76-page manual describing practical methods of applying all known types of coatings to gray iron castings contains 45 illustrations of coated castings. Suggestions are included for improving product appearance. A complete bibliography on each coating process is part of the manual, as well as a list of manufacturers experienced in coating application.

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About EQUIPMENT and SERVICE Suppliers

Leisenring Named Sales Manager

H. D. Leisenring has been appointed sales manager, Pacific Coast area, by the Meter Division of the A. O. Smith Corporation. Leisenring has over 20 years experience in engineering and sales of service station pumps and petroleum meters, and formerly was sales manager of the Pittsburgh Meter Company. He will headquarter in Los Angeles.

Shoudy Is New Executive For Cooling Tower Institute

Cooling Tower Institute has announced the appointment of W. A. Shoudy to executive manager as a further step in its water conservation program. Shoudy is a graduate of Stevens Institute of Technology, serving on its faculty for eight years, and on the Columbia University School of Mechanical Engineering faculty for 14 years. At Columbia he began a consulting practice which he has continued since that time.

Shoudy

In addition he has had twelve years industrial service with such companies as Brooklyn Edison Company, J. G. White Engineering Corporation, American Sugar Refining Company, and others. His office will be at Basking Ridge, N. J.

NEW WORTHINGTON PLANT—The Succasunna Works of the Worthington Pump and Machinery Corporation will be a non-combustible, one-story, unit-type building, measuring 80 x 200 feet, and will be used in the manufacture of vertical turbine pumps. Water supply for the fire-protecting sprinkler system will be furnished by just such a pump and in addition, office space will be air-conditioned by Worthington equipment. Building will contain several bridge-type traveling cranes and will be used primarily for warehousing and assembly work. An engineering room, a test stand for simulating field conditions to check mechanical and hydraulic phases of equipment, and a 35,000-square-foot macadam loading area will be features of the finished plant. It is being established to serve the area east of the Mississippi River as well as customers abroad.

Proportioneers Add Engine Firm

%Proportioneers, Inc.%, Providence, R. I., has acquired Synchro-Master Company, Seneca Falls, N. Y., and will operate the business as its Synchro-Master Division. Sales and production facilities will be located in Providence. Key personnel of the Synchro-Master Company have joined %Proportioneers% and will manage the new division which will produce Synchro-Master units, a mechanical differential for internal combustion engines.

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Pacific Pumps Names Brown Los Angeles Sales Engineer

W. E. Brown will succeed J. W. McCormick, recently transferred to New York, as Pacific Pumps, Inc., Huntington Park, Calif., sales engineer in the Los Angeles district.

Brown holds a mechanical engineering degree from Iowa State College at Ames, and has been employed in various engineering capacities since his graduation in 1941. He specializes in engineering design and sales engineering.

Campbell and Sutherland Given Borg-Warner Promotions

Appointment of G. E. Campbell as assistant works manager and of Donald A. Sutherland as industrial sales manager has been announced by Pesco Products Division of Borg-Warner Corporation.

Campbell formerly was manufacturing consultant in the central offices of Borg-Warner in Chicago. He also has held executive posts with A. O. Smith Company.

Sutherland previously was Pesco's industrial relations manager. Previously he was the division's eastern sales manager for industrial products. E. J. Foltz, previously Sutherland's assistant, has been named industrial relations manager.

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Rockwell Strengthens Nordstrom Sales Staff

Matheson — Bush — Gottwald — Barnett

Four personnel changes in the sales force have been announced by Rockwell Manufacturing Company, Division of Sales, Meter and Valve.

E. E. Matheson, general sales manager for the northern California area, will move to Oakland to assist factory management by acting as liaison between production, engineering and sales.

H. Gottwald, who has been with the organization since 1928, has been named general sales manager for Nordstrom valves.

R. R. Bush, new Oil Field Products sales manager was employed by The Texas Pipe Line Company before joining Rockwell in 1934. He has been a special representative for Nordstrom valves.

O. W. Barnett will be sales manager of warehouse and jobber sales. Last year he was first appointed gas products sales supervisor in the Tulsa area and later assistant sales manager for the Nordstrom Division.

Bird-Archer Consolidates N. Y. Office with Philadelphia Plant

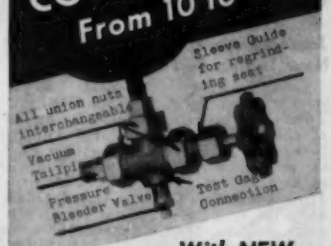
Engineering, sales and service offices of The Bird-Archer Company were moved from 400 Madison Avenue, New York, to 4337 North American Street, Philadelphia, which is the company plant site. The transfer was made so that manufacturing, laboratory, sales and service facilities would be under one roof.

Executive and New York district sales offices will continue at the Madison Avenue address. Water samples, purchase orders and correspondence pertaining to sales, service and other technical matters will be handled at Philadelphia.

Timken Bearing Appoints Reeves Director of Sales

Paul Reeves, a native of Dover, Ohio, has been appointed director of sales for The Timken Roller Bearing Company. A company employe since 1929, Reeves is an alumnus of the company engineering training course and has served as sales engineer at the Chicago office, in-

REDUCE THREADED CONNECTIONS From 10 to 3



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dustrial district manager at San Francisco, sales promotion manager at Canton, Ohio, home office, and was in charge of government priorities and government contracts during World War II.

In 1943 he was appointed advertising manager. Industrial Marketing named him "Industrial Advertising Man of the year" in 1949.

James Anderson Named to Head New Tubing Section of NPA

James S. Anderson, assistant general sales manager of The Babcock & Wilcox Tube Company, has assumed the duties of chief of the newly created Tubing Section of the Iron and Steel Division of the Industries Operations Bureau of the National Production Authority. His headquarters will be in the offices of the NPA in the new general accounting office building, Washington, D. C.

Anderson came to The Babcock & Wilcox Tube Company in 1941 after being associated for a number of years with the Steel and Tubes Division of Republic Steel Corporation.

Rockwell Company Advances Tillman to Sales Engineer Post

J. M. Tillman, newly appointed sales engineer for Rockwell Manufacturing Company, received his engineering degree from Stanford University in 1948. When he joined the company he received his training at the home office in Pittsburgh before being transferred to the Boston district office. He will make his home in Manchester, Conn., while selling gas products and Nordstrom valves in Rhode Island and Connecticut.

Black, Sivalls & Bryson Makes Changes in Oil and Gas Division

Ralph W. Nichols has rejoined Black, Sivalls & Bryson, Inc., as sales manager of its Oil and Gas Equipment division, and will have headquarters at Oklahoma City. Floyd C. Myers, manager of BS&B branch operations, has transferred his headquarters from Kansas City to Oklahoma City, in accordance with the company's policy of concentrating oil, gas and refining business at the latter point.

After graduating from Kansas University in 1926 with degrees in engineering, Nichols served as chief engineer with the Wooded Hills Development Company for two years, and as chief engineer with the Darby Corporation for three years. He then joined BS&B serving successively as estimator, draftsman, engineer, project engineer, contact man and manager of the Fort Worth sales office. From 1945 to near the close of 1950 he was sales manager for the Richmond Engineering Company.

Nichols

Myers

Myers started with BS&B in 1929 as a clerk in the Tulsa office. He was later transferred to sales and service work in Texas, becoming a branch manager in 1935. Five years later he was made assistant credit manager, assuming the duties of credit manager during the war period. Following that, he returned to the branches and became district sales manager for West Texas in 1946.

Black, Sivalls & Bryson's 24-acre Oklahoma City plant is pictured, with dotted lines indicating the new plant and warehouse construction. Center foreground is the three-unit office building.

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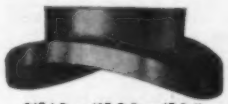
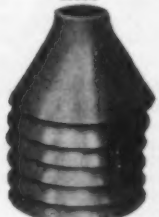
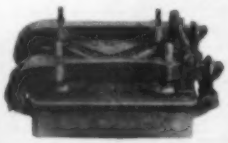


24" I.D. x 43" O.D. x 4" Boiler Saddle



Press formed Rocket Nozzles—5" throat 16" O.D. vent.



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Furnace Company Adds Special Chemical-Petroleum Division

A Chemical and Petroleum Division has been formed by National Airoil Burner Company in Philadelphia to render specialized service to these two industries. William Ferguson, vice president will head the new division which will supply combustion equipment and act as fuel-furnace specialists.

Frederic Bauer, chief technologist, will head the technical staff, and John J. Griffin, chief engineer has been named to head the mechanical engineering staff.

Wilson Names Head of Alcoa Succeeding Veteran Roy Hunt

I. W. Wilson has been elected president of the Aluminum Company of America to succeed Roy A. Hunt, president of the company since 1928. Leon E. Hickman was elected vice president and general counsel; Arthur V. Davis retains the chair of the Board.

Wilson has been with Alcoa for 40 years. *Modern Metals* magazine recently

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elected him "Man of the Year" for 1950 in recognition of his achievements.

Hunt ends a record-setting term as president of Alcoa to become chairman of the executive committee. He is the son of the late Captain Alfred E. Hunt, first president and one of the company founders. Hunt started in 1901 as a machinist's helper.

Hickman is a senior partner in the Pittsburgh law firm of Smith, Buchanan and Ingersoll and has handled many important legal cases for Alcoa during his 25 years experience with the law firm.

De Laval Opens Houston Office Nilsen Is Appointed Manager

De Laval Steam Turbine Company, Trenton, N. J., has appointed T. A. Nilsen district manager of the newly opened Texas district office. New district headquarters will be in the Esperson Building, Houston.

Nilsen

A. N. Sarich, who has been De Laval's Southwest technical representative in Oklahoma and Texas, will continue in the same capacity and will make his headquarters in the new Houston office. De Laval Steam Turbine Company recently supplied a number of the Southwest's major natural gas transmission lines with centrifugal high-pressure natural gas compressors.

Marsh Heads New J. B. Gill Branch Office in Tulsa

J. B. Gill Company recently established a Mid-Continent Division with headquarters at 434 Mayo Building, Tulsa. Branch Manager will be Harry R. Marsh.

Marsh has directed the company's compressor plant and gasoline plant design activity for many years, and will organize the Tulsa office to function as an independent organization offering integrated engineering and construction service to the oil industry, the petro chemical and steel industries.

Fluid Controls Given New ACF Service Area

Fluid Controls Company, Inc., Philadelphia, has been appointed by the Valve Division of American Car and Foundry Company, specialists in industrial control problems and control valves, as representative in the sale and servicing of ACF valves in Delaware, eastern Pennsylvania and western New Jersey. A subsidiary company, Fluid Controls, Inc., New York, already represents the ACF Valve division in the metropolitan New York area.

Laclede-Christy Company Buys Paterson Brick Plant

Laclede-Christy Company of Pennsylvania has purchased the plant and physical assets of Paterson Fire Brick Company at Clearfield, Pa. This plant specializes in Clearfield County stiff-mud clay refractory brick. Additional facilities will be added immediately.

"... paid for themselves in the first year of operation"

The above statement was made by the Chief Engineer of a pipe-line station in Indiana concerning a set of Dura Seals installed on one of their pumps. These mechanical seals are on a main line Crude Oil service pump operating at 3600 RPM, having a suction pressure varying from 10 to 270 lbs. and a discharge pressure into the line averaging 700 lbs.

These single type Dura Seals have just completed five years of continuous operation without shut-down. The Chief Engineer said that he had figured up their previous cost of operation, including new sleeves once a year and labor involved, and that in comparison ". . . these Dura Seals have paid for themselves in the first year of operation."

Learn more about the economy of Dura Seal service by writing the Durametallic Corporation, Kalamazoo, Michigan, asking for Bulletin No. PR-174.

Hays Corporation Names Riggs Engineering Manager

The Hays Corporation has appointed Orval M. Riggs as manager of application engineering.

Riggs

Riggs has had 18 years experience in servicing and selling instruments and will work with customers, consulting engineers and sales representatives to develop further applications of combustion and industrial instruments and controls.

Graduate of Purdue University, Riggs has been with Hays since 1937. Prior to his promotion he was chief project engineer in the sales department. He is active in The ASME and ISA.

Taylor Celebrating Centennial Year of Instrument Manufacture

This is centennial year for Taylor Instrument Companies of Rochester, N. Y., a company that entered the refining field in 1859 by contributing etched-stem thermometers and hydrometers to the refining process. When the tiny partnership opened business in 1851 the books showed an inventory of $919 as total assets, and $600 of this was for "knowledge of the business." It has since become a multi-million dollar corporation manufacturing some 8000 variations of basic products and distributing them all over the world.

George Taylor of Stoddard, N. H., opened business at the age of 19, and kept a journal, now in company archives, which reveals the old-fashioned young man from New England made his entries in shillings and pence long after the rest of the country had changed to dollars and cents.

Taylor got its first government contract from the U. S. Navy just prior to the Spanish-American War, and during World War II the company was selected prime contractor in the development, design and manufacture of all process control instruments for the Gaseous Diffusion Plant of the Atomic Bomb Project at Oak Ridge.

Although instruments for individual use comprise the oldest part of the present Taylor line, by far the largest is the industrial instrument division, which began in 1896 with the acquisition of a firm making mercury-in-glass industrial thermometers for use on batch processes.

Celanese Chem Unit Expands; Personnel Changes Announced

As a result of expanding activities the following personnel changes have been made by the Chemical Division of Celanese Corporation of America. Richard W. KixMiller has been named assistant general manager of the Chemical Division; Kenneth D. Bowen, plant manager at Bishop, Texas, will continue in that post and in addition becomes manager of plant operations of the Chemical Division.

John H. Frick has been appointed plant manager of the new chemical plant to be built at Pampa, Texas, 50 miles east of Amarillo. Also moving to the

13

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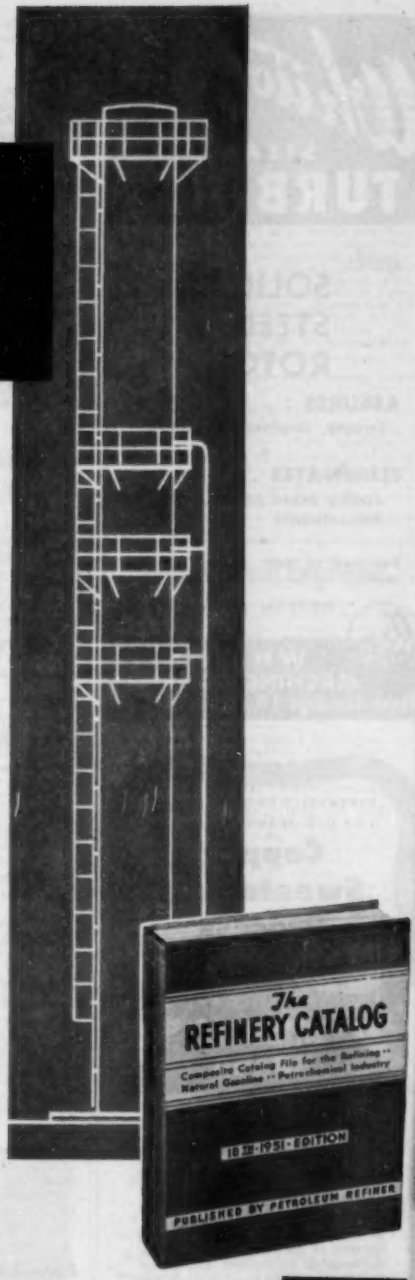
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Panhandle plant site are J. B. Phelps and Robert Clark, as production superintendent and resident engineer, respectively.

William Orr will replace Vincent Anwyll, production superintendent at Bishop. Anwyll is now manager of the Edmonton, Alberta, plant to be erected by Canadian Chemical Company, Ltd., an affiliate of Celanese Corporation of America. David Keck, formerly at Bishop, has been transferred to Edmonton as assistant plant engineer.

H. K. Busch is promoted to assistant production superintendent at Bishop, and Barney C. Martin succeeds Orr as superintendent of the formaldehyde unit. S. T. Ross replaces Busch as superintendent of the products purification unit and Joseph Neely succeeds Phelps as superintendent of the acetic acid unit.

General Controls Promotes Angier to District Manager

General Controls Company, Glendale, Calif., has announced promotion of Fred H. Angier from branch manager in Baltimore to district manager for the Philadelphia and Baltimore factory branch offices. His territory will include the District of Columbia, Maryland, Virginia, West Virginia, eastern Pennsylvania, lower New Jersey and Delaware.

Angier

Angier will headquarter in the general control office at Philadelphia and will direct sales and service activities for automatic pressure, temperature, level and flow controls.

J. B. Crandley, former sales engineer from the Philadelphia office, will succeed Angier at Baltimore.

Foxboro Assembly and Testing Addition Nears Completion

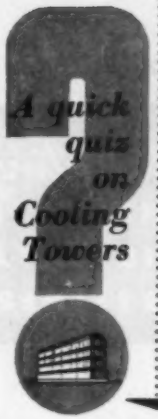
An additional 50,000 square feet will be added to the area of The Foxboro Company at Foxboro, Mass., with completion of a new one-story building that will serve as a connection between the present factory buildings and a new steel and aluminum warehouse recently completed.

The newest building will be used principally for final assembling and testing of recorders and controllers for temperature, pressure, liquid level, and flow. Transfer of this activity from the older buildings will permit expansion of electronic and electric instruments departments and other control equipment areas.

Further construction will include a new training school building which is still in the drawing board stage.

Burrell Corporation Moves To Consolidate Activities

Burrell Corporation's offices and laboratories have been moved to a five-story building at 2223 Fifth Avenue, Pittsburgh, where the company will manufacture and distribute scientific apparatus and laboratory chemicals. Space has been allotted for a customer display room which will be added soon.



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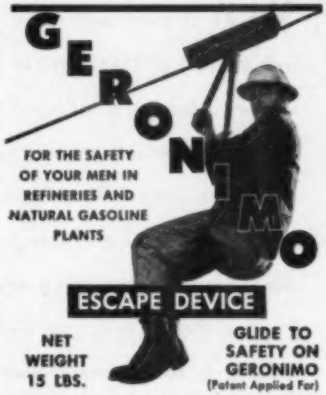

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Corey Elected President Of New Air Clocks, Inc.

Charles D. Corey was elected president of Air Clocks, Inc., Huntington Station, New York. This new company was established to manufacture a line of air-powered timing mechanisms.

Corey

Corey has been connected with various watch and industrial instrument manufacturers for more than 18 years, and is also president of Danco Instruments, Inc.

Air Clocks, Inc., is owned jointly by Danco and Moore Products Company of Philadelphia.

Calco Appoints Dr. Wellman

Dr. Victor E. Wellman has been named director of the Process Engineering Department, Calco Chemical Division, American Cyanamid Company. He will direct process development and chemical engineering activities which were merged to form the Process Engineering Department.

Holder of two graduate degrees from the University of Washington, Wellman was associated with the B. F. Goodrich Company for 15 years, and later with R. W. Greeff Company before joining Calco in 1945. Since 1949 he has been associate director of Process Development.

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Browning Moved to New York

Transfer of J. M. Browning from Westcott & Greis, Inc., Houston, to the American Meter Company's New York office has been announced. He will assist A. B. Cloud, district sales manager.

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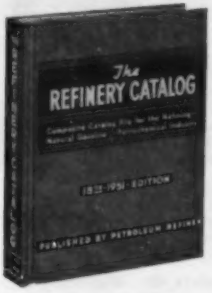

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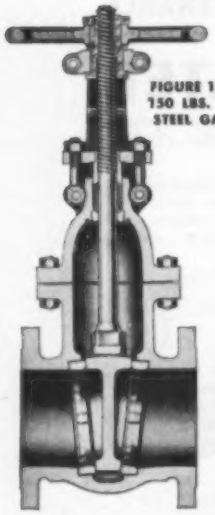

FIGURE 1751
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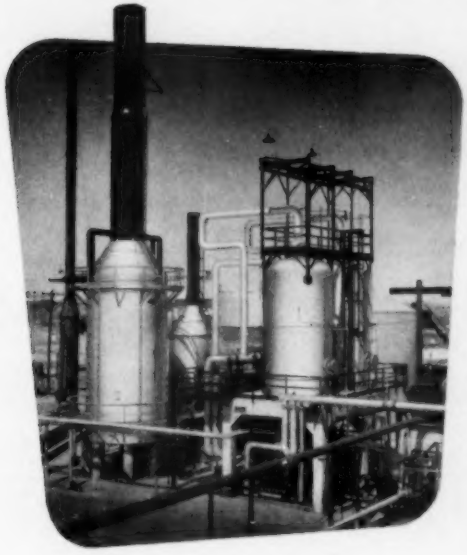

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